

## **06/08/95 ValuJet Airlines**

## Official Accident Report Index Page

**Report Title**

UNCONTAINED ENGINE FAILURE/FIRE VALUJET  
AIRLINES FLIGHT 597 DOUGLAS DC-9-32, N908VJ  
ATLANTA, GEORGIA JUNE 8, 1995

## Facts of the Accident

Accident NTSB ID	96-03
Airline	ValuJet Airlines
Model aircraft	DC-9-32, N908VJ
Aircraft manufacturer	Douglas
Engine type	JT8D-9A
Engine manufacturer	Pratt & Whitney
Date	06/08/95
Time	1855
Location	Atlanta, GA
Country	USA
IFR or VFR?	VFR
Injuries	7
Fire during flight?	-
Fire on the ground?	Y
Probable cause	The failure of Turk Hava Yollari maintenance and inspection personnel to perform a proper inspection on a 7th stage high compressor disk, thus allowing the detectable crack to grow to a length at which the disk ruptured, under normal operating conditions, propelling engine fragments into the fuselage; the fragments severed the right engine main fuel line, which resulted in a fire that rapidly engulfed the cabin area.
Contributing causes	The lack of an adequate record keeping system and the failure to use "process sheets" to document the step-by-step overhaul/inspection procedures contributed to the failure to detect the crack and, thus, to the accident.
Weather conditions	scattered clouds, visibility 12 miles
Total crew size	5
Cockpit crew size	2
Cabin crew size	3
Passengers	57
Report ID	NTSB/AAR-96/03
Pages	131
Day or night?	Dusk
Flight number	597
Flight origin	Atlanta, GA
Flight destination	Miami, FL
Description	As the aircraft began its takeoff roll, a "loud bang" was heard by the airplane occupants and air traffic control

personnel. The right engine fire warning light illuminated, the flightcrew of the following airplane reported to the ValuJet crew that the right engine was on fire, and the takeoff was rejected. Shrapnel from the right engine penetrated the fuselage and the right engine main fuel line, and a cabin fire erupted. The airplane was stopped on the runway and evacuated. The fuselage was destroyed.

This report explains the uncontained engine failure/fire on ValuJet Airlines flight 597, a Douglas DC-9-32, N908VJ, at Atlanta, Georgia, on June 8, 1995. The safety issues discussed in the report include the clarity of operations specifications for repair stations, recordkeeping requirements for foreign repair stations, regulatory guidance concerning maintenance documentation, intent of "serviceable tags," independently powered public address systems on all transport-category airplanes, flight attendant training programs and manuals, enforcement of occupant restraint requirements, notification of flightcrew of cabin fire, cabin material/fire safety standards, flight attendant attire, and quality of cockpit voice recordings. Safety recommendations concerning these issues were made to the Federal Aviation Administration (FAA).

## Executive Summary

On June 8, 1995, a Douglas DC-9-32, N908VJ, was being operated by ValuJet Airlines as a scheduled, domestic passenger flight under the provisions of Title 14 Code of Federal Regulations (CFR) Part 121. Flight 597, destined for Miami, Florida, departed gate C25 at the William B. Hartsfield Atlanta International Airport, Atlanta, Georgia, at 1855, and was cleared for takeoff on runway 27R at 1908. Five crewmembers and 57 passengers were on board.

As flight 597 began its takeoff roll, a "loud bang" was heard by the airplane occupants and air traffic control personnel. The right engine fire warning light illuminated, the flightcrew of a following airplane reported to the ValuJet crew that the right engine was on fire, and the takeoff was rejected. Shrapnel from the right engine penetrated the fuselage and the right engine main fuel line, and a cabin fire erupted. The airplane was stopped on the runway, and the captain ordered the evacuation of the airplane.

The flight attendant seated in the aft flight attendant jumpseat received serious puncture wounds from shrapnel and thermal injuries. Another flight attendant and five passengers received minor injuries. The pilots, the third flight attendant, and 52 passengers were not injured. The airplane's fuselage was destroyed.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of Turk Hava Yollari maintenance and inspection personnel to perform a proper inspection of a 7<sup>th</sup> stage high compressor disk, thus allowing the detectable crack to grow to a length at which the disk ruptured, under normal operating conditions, propelling engine fragments into the fuselage; the fragments severed the right engine main fuel line, which resulted in a fire that rapidly engulfed the cabin area. The lack of an adequate recordkeeping system and the failure to use "process sheets" to document the step-by-step overhaul/inspection procedures contributed to the failure to detect the crack and, thus, to the accident.

The safety issues in this report include the clarity of operations specifications for repair stations, recordkeeping requirements for foreign repair stations, regulatory guidance concerning maintenance documentation, intent of "serviceable tags," independently powered public address systems on all transport-category airplanes, flight attendant training programs and manuals, enforcement of occupant restraint requirements, and cabin material/fire safety standards.

Safety recommendations concerning these issues were addressed to the Federal Aviation Administration.

## **1. Factual Information**

## 1.1 History of the Flight

On June 8, 1995, a Douglas DC-9-32, N908VJ, was being operated by ValuJet Airlines as a scheduled, domestic passenger flight under the provisions of Title 14 Code of Federal Regulations (CFR) Part 121. Flight 597, destined for Miami, Florida, departed gate C25 at the William B. Hartsfield Atlanta International Airport, Atlanta, Georgia, at 1855, and was cleared for takeoff on runway 27R at 1908. Five crewmembers and 57 passengers were on board.

As flight 597 began its takeoff roll, a "loud bang" was heard by the airplane occupants and air traffic control personnel. The right engine fire warning light illuminated, the flightcrew of a following airplane reported to the ValuJet crew that the right engine was on fire, and the takeoff was rejected. Shrapnel from the right engine penetrated the fuselage and the right engine main fuel line, and a cabin fire erupted. The airplane was stopped on the runway, and the captain ordered the evacuation of the airplane.

After the airplane came to a stop, the forward flight attendants opened the forward passenger boarding door and the service door exits, and the airplane was evacuated. The flight attendant at the service door exit stated that when the door was opened, the cabin filled with smoke from about waist level up to the ceiling.

The flight attendant seated in the aft flight attendant jumpseat received serious puncture wounds from shrapnel and thermal injuries and evacuated herself from the airplane through an overwing exit. Another flight attendant and five passengers received minor injuries. The pilots, the third flight attendant, and 52 passengers were not injured. The airplane's fuselage was destroyed.

The accident occurred at dusk. The airplane came to a stop about 1,500 feet down runway 27R, before taxiway M18, approximately 33° 38'04" North latitude and 84° 24'50" West longitude([see figure 1](#))

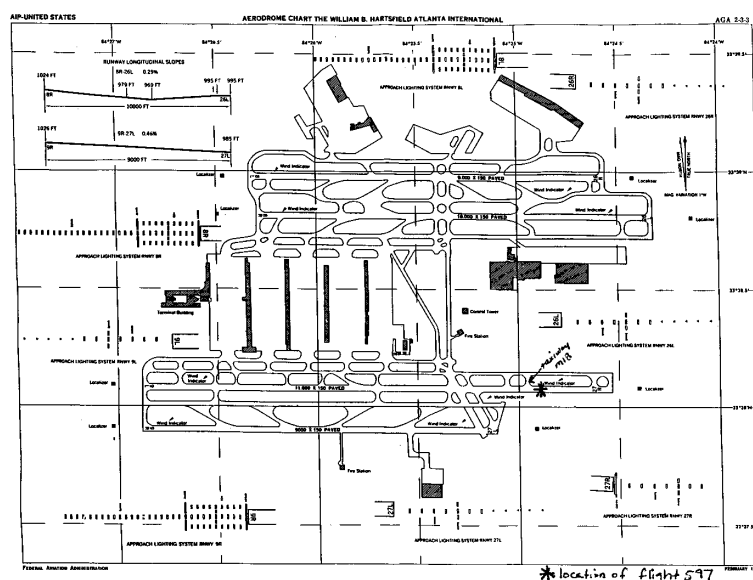


Figure 1—Location of flight 597 at Hartsfield Atlanta

## 1.2 Injuries to Persons

Injuries	Cockpit crew	Flight attendants	Passengers	Other	Total
Fatal	0	0	0	0	0
Serious	0	1	0	0	1
Minor	0	1	5	0	6
None	2	1	52	0	55
Total	2	3	57	0	62



### 1.3 Damage to Aircraft

The fuselage was destroyed by fire, which gutted the interior, burned through the roof of the forward cabin area of the airplane, and consumed most of the cabin overhead. There was substantial exterior damage with circumferential outward tearing of the right engine cowl and engine case in the plane of rotation of the right engine 7<sup>th</sup> stage high pressure compressor (HPC) disk. There was also shrapnel damage to the fuselage and left engine cowl.

## 1.4 Other Damage

No other property damage resulted from this accident.

## 1.5 Personnel Information

The flightcrew consisted of the captain and the first officer. Three flight attendants were aboard the airplane.

### 1.5.1 The Captain

The captain, age 45, was hired by ValuJet Airlines on November 25, 1993, as a captain on DC-9 airplanes. He held an airline transport pilot (ATP) certificate, with an airplane multiengine land rating, and DC-9, Boeing 737, and Lear Jet type ratings. He had commercial pilot privileges for airplane single-engine land. He was a certified flight instructor with airplane multiengine and instrument airplane ratings.

The captain's first-class medical certificate was issued on March 21, 1995, with no restrictions or limitations.

The captain was a designated pilot examiner for Boeing 737 airplane type ratings. His last proficiency check was completed on May 7, 1995, in the DC-9 airplane. According to company records, the captain had accumulated about 9,500 total flight hours, with about 3,500 hours in the DC-9, and 2,500 hours as a DC-9 captain. The captain had about 11 years previous experience with Eastern Airlines as a DC-9 captain and first officer, a Boeing 727 first officer, and a Lockheed L-1011 second officer.

The captain reported for duty on the day of the accident at 1332, following 3 days off duty.

### 1.5.2 The First Officer

The first officer, age 43, was hired by ValuJet Airlines on October 28, 1994, as a first officer on the DC-9 airplane. He held an ATP certificate with airplane single-engine and multiengine land ratings.

His first-class medical certificate was issued on September 14, 1994, with no restrictions or limitations. The first officer's last proficiency check was completed on May 29, 1995, in the DC-9 airplane. According to company records, he had accumulated about 3,800 total flight hours with 552 hours in the DC-9, all as first officer. The first officer had previous flight experience in a Lockheed P-32 with the United States Navy, between 1982 and 1991.

The first officer reported for duty on the day of the accident at 1328, following 2 days off duty.

### 1.5.3 Flight Attendants

Two flight attendants occupied the aft-facing double-occupancy jumpseat in the forward cabin at the time of the accident. One of the flight attendants had completed her initial ValuJet training on November 15, 1994. She had been previously employed as a flight attendant with Eastern Airlines for 7½ years and with Private Jet for 1½ years. She was scheduled for her first recurrent training in November 1995.

The other flight attendant in the forward section of the cabin had completed her initial training on December 15, 1994. She had no prior flight attendant experience. She was scheduled for her first recurrent training in December 1995.

The flight attendant who occupied the jumpseat in the rear cabin had completed her initial training on December 23, 1993. She had no prior flight attendant experience. Her most recent recurrent training before the accident was completed in November 1994.

## 1.6 Aircraft Information

### 1.6.1 Aircraft Origin and Configuration

N908VJ, a Douglas DC-9-32, serial number (SN) 47321, was registered to ValuJet Airlines. The airplane was purchased from the Douglas Aircraft Company and was put into service as part of ValuJet's fleet on February 4, 1994. It had previously been operated by Delta Air Lines. The airplane was powered by two Pratt & Whitney (P&W) JT8D-9A turbofan engines. The right engine, SN 666966, was installed on the airplane in March 1995. It had been obtained by ValuJet from Turk Hava Yollari (THY) A.O., Turkish Airlines, in a large equipment purchase on October 3, 1994, that included a total of 23 engines.<sup>3</sup> THY is a Turkish domestic and international airline that also operates an airframe and engine repair station.

At the time of the accident, flight 597 had a basic operating weight of 61,564 pounds and a takeoff weight of 96,374 pounds; maximum takeoff weight for this DC-9-32 was 102,900 pounds. The center of gravity was at 23 percent mean aerodynamic chord, which was within limits. During the pre-departure preparations, the flightcrew noted that the traffic collision and avoidance system (TCAS) fail light remained illuminated. The minimum equipment list for the accident aircraft indicated that the TCAS was not required for flight, and at the time of the accident, this discrepancy could be left uncorrected for up to 10 days.

The airplane was configured with 108 passenger seats. Supplemental oxygen for both the flightcrew and the passengers was provided by compressed oxygen-filled bottles.

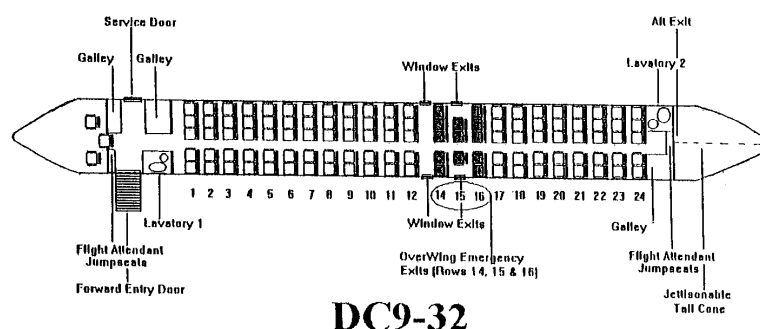
Two floor-level exits were located in the forward cabin, four overwing exits were located at rows 14 and 16, and a tailcone exit was located at the rear of the cabin.[\(See figure 2.\)](#) Two cockpit windows could be used as emergency exits.



## 1.6.2 Emergency Lighting and Power

The airplane was equipped with a cabin floor path emergency lighting system, which, along with other emergency lights, provides illumination in the main cabin when the normal electrical power is interrupted. The emergency lighting system was installed in accordance with a supplemental type certificate.<sup>4</sup> The emergency lighting system is powered by either the Emergency direct current (DC) Bus or dedicated rechargeable battery packs and is controlled by a three-position emergency lighting switch with positions "ON," "OFF," and "ARMED" located in the cockpit overhead panel. The Emergency DC Bus is normally powered by engine-driven generators. It can also be activated by manually selecting emergency electrical power. Placing the emergency lighting switch to "ON" illuminates the emergency lights when the Emergency DC Bus is powered. The "ARMED" position is the normal flight position, which turns off the emergency lights and causes the battery packs to be charged. The "OFF" position extinguishes the lights and discontinues the charging of the batteries.

If electrical power to the Emergency DC Bus is interrupted, the emergency lights automatically illuminate (if the emergency lighting switch is in the "ARMED" position), with the electrical power provided by the battery packs. The manual selection of emergency electrical power restores power to the Emergency DC Bus from the aircraft's batteries; however, unless the emergency light switch is first moved from the "ARMED" to the "ON" position, this action will also extinguish the emergency lights and resume charging of the battery packs. Placing the cabin emergency lighting switch to the "ON" position was the fourth item on the ValuJet Emergency Evacuation Checklist.<sup>5</sup>



**Figure 2—DC9-32 cabin configuration**

The airplane was equipped with a public address (PA) system that enabled the flightcrew and flight attendants to address occupants through loudspeakers located throughout the cabin. The PA system is also powered by the Emergency DC Bus. An interruption of electrical power to the Emergency DC Bus disables the PA system. Manual selection of emergency electrical power restores power to the PA system.

## 1.7 Meteorological Information

Visual meteorological conditions prevailed at the time of the accident.

The Hartsfield Atlanta International Airport hourly weather observation at 1850 was: sky—scattered clouds, ceiling at 5,500 feet; visibility—12 miles; temperature—93 °F; dew point—71 °F; wind—290° at 8 knots; and altimeter setting—29.99. The weather was essentially the same at the next hourly observation.

## 1.8 Aids to Navigation

There were no known difficulties with aids to navigation.

## 1.9 Communications

There were no known external communication difficulties involving the airplane. The flightcrew of Delta flight 846, which had been cleared to "position and hold" behind flight 597, advised the ValuJet crew of a fire in the right engine, prompting the captain to reject the takeoff and stop the airplane on the runway.

After the captain stopped the airplane and the engines were shut down, he attempted to communicate to the passengers using the PA system but was unable to do so. After the captain selected emergency electrical power, the power was restored to the PA system, and the captain successfully communicated the evacuation order.

One of the flight attendants in the forward section of the cabin saw flames around the flight attendant in the aft jumpseat and tried to notify the flightcrew of the fire by opening the cockpit door. As required by FAA regulations, the cockpit door was locked. While one of the forward flight attendants reached for the cockpit door key, which had been stored in the galley per ValuJet procedures, the other flight attendant successfully opened the cockpit door with her own key and informed the flightcrew of the fire. The captain then ordered an evacuation through the forward exits.

According to ValuJet's flight attendant manual in effect at the time of the accident:

If life threatening conditions exist inside the cabin, the first crewmember aware of the situation shall notify the pilots via the interphone using the emergency signal (six chimes).<sup>6</sup> If no response, unlock the cockpit door and evaluate conditions. If able, the captain will evaluate the situation and, if necessary, initiate an evacuation with the PA announcement of Evacuate, Evacuate, Evacuate

The flight attendant manual further provides that "If a life threatening situation exists inside the cabin, and you are unable to contact the cockpit, begin shouting the appropriate commands. Once the aircraft comes to a complete stop, initiate the evacuation. Note: An evacuation should not be initiated until the aircraft has come to a complete stop."

## 1.10 Airport Information

The William B. Hartsfield Atlanta International Airport is located 6 miles **south** of Atlanta, Georgia. It is served by four parallel runways oriented east/west. The terminal building and passenger loading concourses are situated between the two innermost parallel runways. Runway 27R, used by ValuJet flight 597, is the runway closest to the terminal on the **south** side of the terminal/concourse area. Departure operations are normally conducted from the inner runways, with landing operations normally conducted on the outer runways. Runway 27R is 11,889 feet long and 150 feet wide. The approach threshold elevation is 978 feet mean sea level.

Hartsfield International Airport is fully certificated under 14 CFR Part 139 and is an Index E Aircraft Rescue and Fire Fighting (ARFF) facility.[7](#)

## 1.11 Flight Recorders

Digital flight data (DFDR) and cockpit voice (CVR) recorders were installed in the airplane. The DFDR was a Fairchild Model F800, SN 05466, with an 11-parameter recorder, with two channels that were not recording properly. The CVR was a Fairchild Model A-100A, SN 53333. Both recorders were removed from the airplane and sent to the Safety Board's laboratory in Washington, D.C., for readout.

The cases of both recorders were intact and covered with a light sooting. An excellent recording was obtained from the DFDR, and a recording of fair quality<sup>8</sup> was obtained from the CVR. There was no apparent interior heat or impact damage to the CVR.

Data from the DFDR indicated that the engine pressure ratio (EPR) on both engines began increasing shortly after flight 597 was cleared for takeoff. The airplane accelerated for about 14 seconds, reaching an indicated airspeed of about 31 knots when the right engine EPR decreased from about 1.57 to about 0.91 within 1 second.

The CVR recording consisted of three channels: the cockpit area microphone, the pilot audio panel, and the interphone/PA system. The cockpit area microphone channel recording contained background noise that nearly obliterated the pilots' voices and made them difficult to understand. A transcript was prepared of the entire 31-minute, 16-second recording. The transcript of the CVR is contained in appendix B of this report.

The CVR recording started at 1838:03, with the airplane at the gate being prepared for departure. It continued through the flightcrew's preparations for departure, taxi, and takeoff. The recording ended after engine shutdown with the airplane stopped on the departure runway.

## 1.12 Wreckage and Impact Information

The airplane stopped on the centerline of runway 27R, about 1,500 feet west of the approach end of the runway. Debris from the right engine was found on the runway, from about 100 feet west of the runway threshold to the stopped airplane. Additional engine debris was found in the grass areas on either side of the runway. The overwing exit hatch from the right side of passenger seat row 14 was found on the runway, about 1,200 feet west of the runway threshold.

### 1.12.1 Right Engine

The right engine, SN 666966, remained attached to the pylon structure. The nacelle doors were closed, and all four latches were locked. A circumferential tear of the engine nacelle encompassed the upper and lower nacelle doors from approximately the 9 o'clock position clockwise to the 6 o'clock position.<sup>9</sup> The circumferential opening was approximately 14 inches wide and about 67 inches aft of the engine inlet flange. The circumferential tear of the right engine nacelle was aligned with the rotational plane of the 7<sup>th</sup> stage HPC disk. The torn edges were ragged and curled outboard, away from the center of the engine. The forward edges of the hole were burned, with the paint blistered and charred. The nacelle was heat damaged from about the 1 to 6 o'clock position, to about 15 inches forward of the circumferential opening. The nacelle lower half was covered with soot aft of the circumferential opening.

The fan discharge outer rear duct and the compressor case were also circumferentially ripped open through 360° and about 8 inches wide, directly behind the intermediate case (G flange). A 1-inch-wide strip of fan duct skin remained at the 6 o'clock position.

All of the 1<sup>st</sup> stage fan blades were in place in the fan disk with varying degrees of hard body impact damage to the airfoil leading and trailing edges, outboard of the midspan shrouds. The airfoil trailing edge tips were bent forward.

Only two pieces of the fractured 7<sup>th</sup> stage HPC disk, SN G78851, were recovered.<sup>10</sup> One piece, about half of the disk, was found resting on the accessory gearbox, visible through the circumferential tear in the cowling. The section of disk, which previously formed the bore for the missing half of disk, was straight and extended tangentially from the inner diameter of the disk. The straightened section of disk bore protruded radially out through the circumferential opening in the compressor case and nacelle at the 5 o'clock position. The 7<sup>th</sup> stage compressor blades retained in the disk were bent opposite the direction of rotation.

The 6<sup>th</sup> stage airseal was separated from the 7<sup>th</sup> stage disk. The airseal was bent and fragmented. About 60 percent of the airseal was recovered. The largest fragment, comprising about 150° of arc, was found lodged in the nacelle, against the pylon. Additional pieces were recovered from the accident runway and adjacent area.

The 8<sup>th</sup> stage compressor disk and hub were visible through the circumferential opening in the fan duct and compressor case. Several 8<sup>th</sup> stage compressor blades were missing from their respective blade slots. The remaining blades had hard body damage on the leading edges. All of the compressor tierods were fractured at the 8<sup>th</sup> stage disk. Most of the tierod fractured ends protruded out of the 8<sup>th</sup> stage disk and were bent radially outward from their respective holes.

The thrust reverser and turbine exhaust case appeared undamaged by the event. The turbine exhaust case had metal fragments lying on the bottom of the case.

The forward, upper portion of the gearbox case, behind the fuel pump and control mount pad, was fractured, exposing the internal drive gears. The gearbox mounting lugs were fractured, and the gearbox was below the running position. The radial driveshaft from the gearbox to the intermediate case was disengaged. Oil and fuel lines to the gearbox and its associated accessories were intact. The hydraulic pump housing and main fuel pump separated from their respective gearbox mount pads.

The two pylon vibration absorbers and their respective attachment bolts, aft of "G" flange, were fractured. The pylon vibration absorbers are in the plane of rotation of the 7<sup>th</sup> stage disk.

Thirty-three 7<sup>th</sup> stage compressor blades were retained in the larger piece of the 7<sup>th</sup> stage disk, which was found inside the engine. An arc of 8 and an arc of 11 adjacent blades were bent opposite the direction of rotation. An arc of 14 blades was transversely fractured, adjacent to the blade platform.

The smaller piece of the 7<sup>th</sup> stage disk was recovered from runway 27R, left of the centerline. The smaller piece of the 7<sup>th</sup> stage disk had six blades retained in the rim. The blades were transversely fractured adjacent to the blade platforms.

The two pieces of the 7<sup>th</sup> stage HPC disk were shipped to the Safety Board's materials laboratory in Washington, D.C., for examination. (See section 1.16.1 of this report for details of the disk examination.)



### 1.12.2 Left Engine

The left engine (SN 666055) nacelle had a dent and a 1/4-inch-diameter puncture at about the 4 o'clock position in line with a series of holes through the fuselage. Inspection of the engine inlet, inlet guide vanes, fan, and 4<sup>th</sup> stage blades did not reveal any damage. There was no fire damage. The examination of the left engine and data from the DFDR provided no evidence of problems with the left engine. The left engine was not disassembled or tested.

### 1.12.3 Fuselage

Several punctures were observed in the fuselage above and below the right engine pylon. The largest puncture was adjacent to the right engine main fuel line. A 6-inch section of the fuel line was severed where it passed through the aft lavatory sidewall, about 1 foot above the cabin floor. The lavatory door had an approximate 1-foot-diameter puncture hole adjacent to the forward door frame. The galley's forward frame had a piece of the corner post missing with the metal smeared to the left side of the airplane. The galley cooler box<sup>11</sup> had grooves across its front side. The left side of the fuselage under the engine pylon had a puncture hole with outward bent edges, consistent with a projectile penetrating the left side of the fuselage from inside to outside. A rope was used to establish that the hole in the right side of the fuselage, the hole in the lavatory door, damage to the galley cooler and frame, the exit hole in the left side of the fuselage, and the dent in the left engine cowl were all aligned.

Fire damage inside the aft lavatory was less severe than the fire damage elsewhere in the passenger cabin. The cabin floor support beam at the forward edge of the lavatory, which extended from sidewall to sidewall, was nearly burned through at the center. The section of cabin floor surrounding the beam was partially melted and burned. The cargo bay liner beneath the aft lavatory was charred on the top and sides. Wire bundles and conduits between the cabin floor and the cargo bay liner in the same area as the damaged floor beam were more severely burned than in adjacent areas. The injured flight attendant's jumpseat was immediately aft of the center aisle section that was nearly burned through. The jumpseat was also just aft of the path made by the rope used to establish the relationship between the right side fuselage hole and the dent in the left engine cowl.

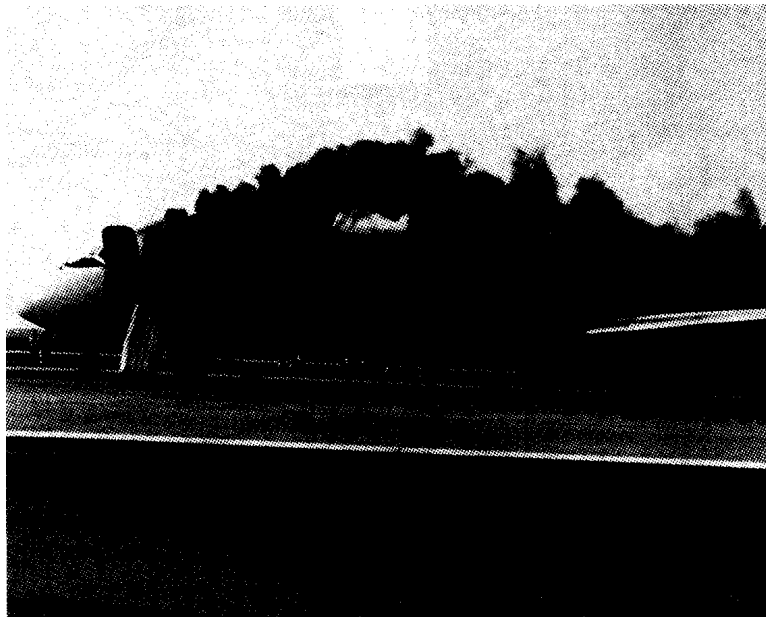
The top of the cabin, above the cabin windows, was consumed by fire from the 2<sup>nd</sup> window rearward to about the 15<sup>th</sup> window. There was severe interior fire damage to the entire passenger cabin, with sooting and blackening of the interior of the cockpit. The seat fabric, carpet, and cabin interior material were nearly consumed by the fire.

The evacuation slides at both forward floor-level exits were found deployed and inflated. All overwing exit hatches were absent. One overwing exit hatch was found on the runway along the debris trail. The passenger seated in 14E stated that he opened the right overwing exit hatch located by his seat and threw it from the airplane. His companion seated in 14C confirmed that account. The passenger seated in 20C stated that when he moved to the right side overwing exits, another passenger removed one of the exit hatches and handed it to him, and he laid it in the adjacent seat. A third hatch was found adjacent to the aft window frame forward of row 16, on the left side of the airplane. It was not determined how the left overwing exit hatches were removed. Soot trails on the exterior of the aircraft extended up and aft from the overwing exits and the forward doors. Photographs taken by a passenger and provided to the Safety Board showed flames visible at the overwing exit and smoke at the forward and overwing exits.<sup>(See figure 3.)</sup> The tailcone, aft of the rear pressure bulkhead, was in place and not burned.

In the cockpit, the emergency power switch was found in the "ON" position, and the emergency lighting switch was in the "ARMED" position. The left and right engine fire handles were in the aft, or activated position.<sup>12</sup> Both fuel shutoff valves were in the closed position and both fire suppression bottles had been discharged into the right engine.

### 1.13 Medical and Pathological Information

Five passengers sustained minor lacerations and contusions during the evacuation. They were treated at the scene, transported to local medical facilities for hyperventilation and smoke inhalation, and released the same day. The aft flight attendant sustained second degree burns on her legs, and two puncture wounds above and below the inside of her left knee. She was wearing shorts and a short-sleeved polo shirt—ValuJet's flight attendant manual in effect at the time listed standard uniform items for ValuJet flight attendants as trousers, shorts (optional), polo shirt (short or long sleeve), sweater (optional), a jacket, white socks, and white shoes. Unidentified pieces of the airplane debris were removed from the flight attendant's leg by medical personnel.



**Figure 3—Photograph of flight 597 after uncontained engine failure**

In accordance with ValuJet's FAA-approved program, the flightcrew provided postaccident toxicological samples for analysis. The samples were analyzed and found to be negative for ethanol and other drugs of abuse. In addition, samples were requested from and provided by the two flight attendants who were not injured. These were likewise negative. Although a sample was requested from the flight attendant who had been injured, the request was received after she had been hospitalized and treated for her injuries. Consequently, no toxicological sample was obtained.

## 1.14 Fire

According to passenger statements, within seconds after the takeoff roll began, a sound was heard that was described as a loud bang or explosion. Passengers reported looking rearward in the direction of the sound and observing flames and fuel around the aft flight attendant. The flight attendant seated in the forward jumpseat stated that within a few seconds after the takeoff began, she heard a loud bang, saw flashes, and could clearly see smoke and flames around the feet of the flight attendant seated in the aft cabin. The fire that began in the aft fuselage rapidly spread through the airplane and consumed the fuselage.

### 1.14.1 Emergency Response

At 1908, the local control supervisor in the Atlanta Air Traffic Control Tower notified the Atlanta Fire Department at the airport of the ValuJet emergency. Battalion 7 of the Atlanta Fire Department was dispatched and arrived at the scene at 1911. Additional firefighting units arrived on the scene at 1913. When the Atlanta Fire Department units arrived, all occupants had evacuated the airplane. The two flight attendants in the forward section of the airplane and the first officer reported that shortly after they exited the airplane following the passengers, the firefighting vehicles arrived on scene. According to the Atlanta Fire Department report, arriving units could see fire near the No. 2 (right) engine and heavy smoke emanating from all exits. Firefighting personnel reported that the fire was spreading rapidly through the airplane from rear to front. An interior attack was initiated on the cabin fire. According to firefighting personnel, after noting the rapid progress of the fire along the overhead area and because the evacuation had been completed, the firefighters retreated and continued fire suppression efforts from outside the airplane. The fire was brought under control about 1922 and extinguished about 1925.

## 1.15 Survival Aspects

The cockpit was configured conventionally with two flight crewmember seats and an observer jumpseat. No one occupied the observer jumpseat. The two flight attendants in the forward section were seated on an aft-facing double-occupancy jumpseat attached to the cockpit bulkhead, adjacent to the forward entry door. The flight attendant in the aft cabin was seated in a forward-facing jumpseat attached to the aft cabin exit door.

About ½ of the available cabin seats were occupied. The ValuJet passenger manifest listed one lap child. That lap child (a female) was older than 24 months old. Title 14 CFR Part 121.311(b) requires that all passengers more than 24 months of age be restrained during takeoff and landing. According to passenger interviews, the child was seated on the lap of a female adult in the 21-E window seat. During the evacuation, the adult handed the child to a male passenger who carried the child through the right overwing emergency exit to another passenger who carried the child across the wing and, holding the child, jumped off the trailing edge of the wing to the runway without injury.

All exits and evacuation slides, except the tailcone exit (which was blocked by the aft cabin fire), were unobstructed and were used during the evacuation. Some passengers who saw the fire in the aft section of the cabin released their seat belts and moved toward exits before the airplane came to a stop.

The captain reported that as he and the first officer were accomplishing the evacuation checklist, the smoke in the cockpit became thick, black, and acrid, and was lowering rapidly. The first officer reported that he was reading the evacuation checklist and had verified that the brakes were set and that the spoilers were retracted, had lowered the flap handle, and had pulled the No. 1 engine fire handle (the captain had pulled the No. 2 handle), after which he could hardly breathe. The first officer stated that he then yelled to the captain that "we've got to get out of here," before they were able to place the emergency light switch (the fourth, and next, item in the evacuation checklist) in the "ON" position.

The captain reported that as the first officer stood up, he could not see him from the chest up. According to the first officer, when he exited the cockpit into the cabin, he could feel people walking past him but could see them only from the waist down. He stated that when he no longer felt anyone passing by, he exited through the front left door of the airplane. The captain stated that when he exited the cockpit, he dropped to the floor and could see "some distance down the aisle, but only within about 3 to 4 inches of the floor." According to passengers, the fire spread rapidly and fully engulfed the cabin area within about 3 minutes after the engine failure.

Passengers reported that during the evacuation, the emergency floor track lighting illuminated briefly but then extinguished. Also, as mentioned previously, the captain reported that his initial attempt to broadcast the evacuation announcement over the PA system had not been successful; he then moved the emergency power switch to the "ON" position (which caused the emergency lights to turn off) and repeated the announcement.

One passenger reported that the injured flight attendant in the aft jumpseat was struggling to release her seat belt and that as he moved aft to assist her, she released the belt and moved forward to escape through a left overwing exit.

Several passengers described difficulty with visibility because of the smoke.

## 1.16 Tests and Research

### 1.16.1 Metallurgical Examinations

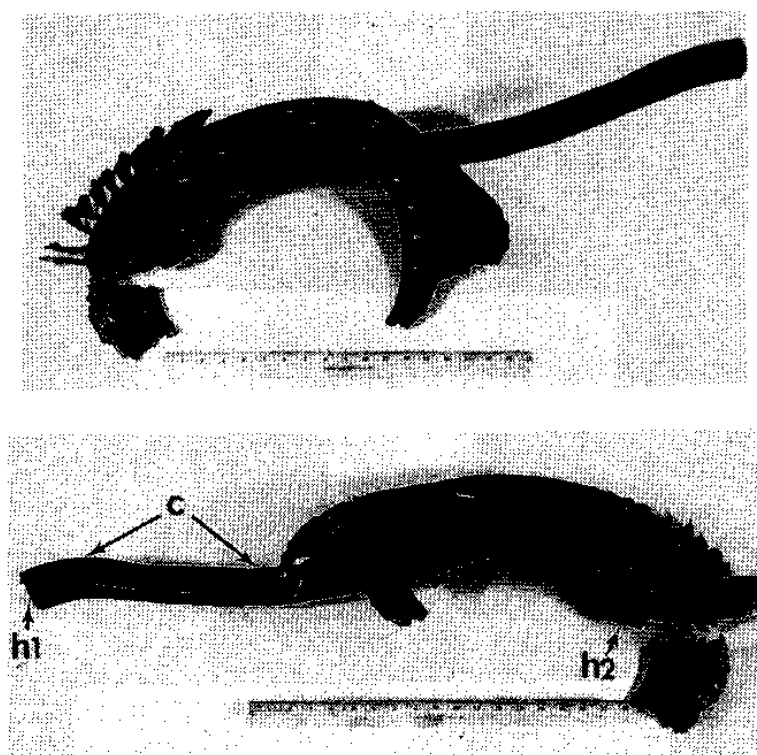
The Safety Board disassembled the failed engine at the AeroThrust Corporation in Miami, Florida.<sup>13</sup> Following the disassembly, parts, including the recovered portions of the failed 7<sup>th</sup> stage HPC disk, SN G78851, were taken to the Safety Board's materials laboratory for further examination. Maintenance records for the engine indicated that the disk had accumulated 24,101 hours and 16,340 cycles. It had a life limit of 30,000 hours or 18,932 cycles.<sup>14</sup>

The larger piece of the recovered disk was fractured circumferentially (see arrows "c," [figure 4](#)), which is typical of overstress. About ¼ of the disk outward (toward the rim) of the bore was separated and not recovered. There was a radial fracture of the disk bore at the position shown by arrows "h1" and "h2" in [figure 4](#). Examination of these fractures showed that they were matching overstress separations and therefore accounted for the complete separation of the bore section of the disk.

Twenty-four evenly spaced holes are machined in the web area of the disk. twelve of these holes are known as stress redistribution (SR) holes,<sup>15</sup> also referred to as shielding holes in the engine manual. Alternating with these SR holes are 12 slightly larger holes known as tierod holes, through which the tierods are put to clamp the disk to the mating disks and spacers in the complete engine assembly.

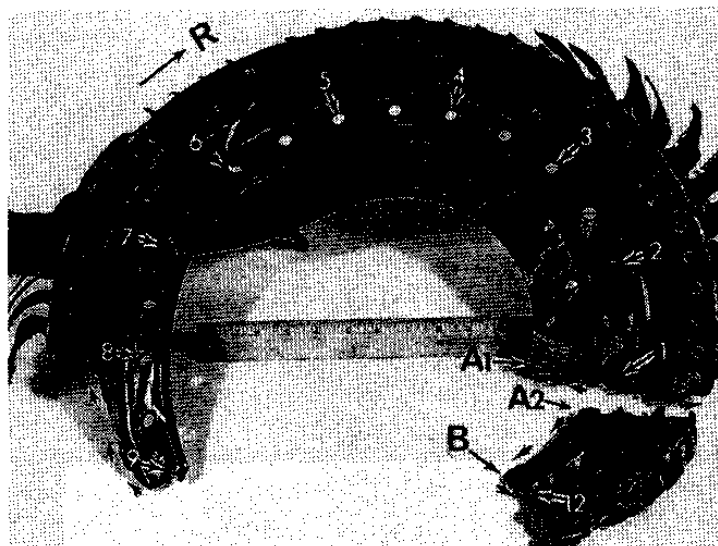
[Figure 5](#) shows the aft face of the two recovered pieces situated relative to each other by fracture matching. The SR holes are shown by arrows "1" through "9" and arrow "12" in [figure 5](#). The SR hole numbering was arbitrarily begun at the radial fracture plane indicated by arrows "A1" and "A2" in [figure 5](#) and progressed sequentially counterclockwise looking forward around the disk (as shown in [figure 5](#)). The missing section of web would have contained SR holes "10" and "11" in the above numbering sequence, and three tierod holes.

Scanning electron microscope (SEM) examination established that fatigue cracking originated from numerous pits in the hole wall and progressed radially inboard (toward the center of the disk) from SR hole "1," approximately 6.9 millimeters (mm) (0.27 inch). SEM examination also showed evidence of fatigue cracking outboard (toward the rim) from SR hole "1" that measured 22.25 mm (0.88 inch). [Figure 6](#) shows the fracture surface containing the primary fatigue crack.

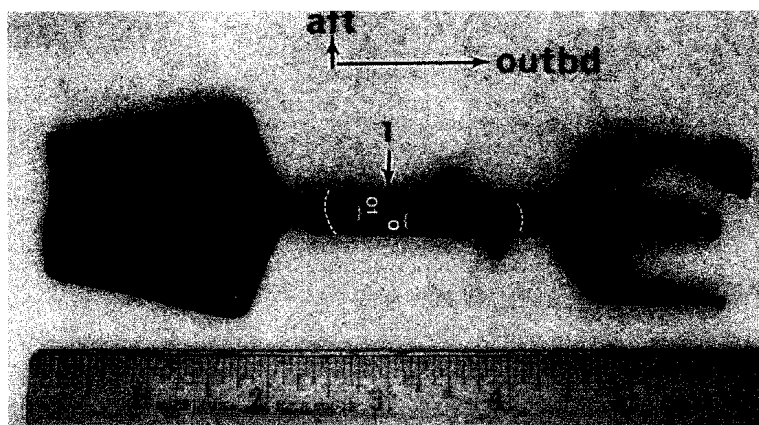


**Figure 4—Overall views of 7th stage compressor disk as received**





**Figure 5—View looking forward showing bulk of the 7th stage compressor disk**



**Figure 6—Fracture surface containing the primary fatigue cracking**

Energy dispersive x-ray analysis of the pits on the hole wall revealed cadmium-rich deposits<sup>16</sup> with some nickel. Cadmium-rich deposits were also found on the fracture surface adjacent to the pits and hole wall.

Visual and SEM examinations of the outboard fracture surface from SR hole "1" showed extensive post-fracture smearing that obliterated most of the microscopic fracture features on the fracture surface. However, some undamaged fracture areas were found that indicated an origin area at the outboard wall of SR hole "1." Features outside of the smeared region up to a distance of about 3 mm (0.12 inch) showed a granular appearance with no evidence of striation development. At this point, fatigue striation development was noted that continued outboard approximately 22.25 mm (0.88 inch) from SR hole "1."

Striation spacing measurements of the fracture surface of SR hole "1" were attempted but hampered by the smearing in the fracture surface. The striation spacing in the granular type fracture regions near the origin were possibly unresolvable or nonexistent. Striation spacings outside of the granular fracture regions and smearing for the outboard fatigue crack from SR hole "1" averaged about 2 microns (0.002 mm) from about 3 mm to the terminus at 22.25 mm. This indicated that at least 9,500 striations (19 mm/0.002 mm per striation) were present along this fatigue region.

Fatigue cracking was also evident radiating outboard from other SR holes, indicated by arrows "4," "6," "8," "9," and "12" in [figure 5](#). The largest of these fatigue cracks was 5 mm (0.20 inch) outboard from its respective hole. Most of the secondary cracks appeared to initiate at well-defined corrosion pits in the hole wall with the largest and deepest pit measuring 0.01-inch wide at the hole wall and being about 0.003-inch deep. Magnified examination of the cross section of the crack disclosed a surface deposit on the pit cavity wall and hole wall surfaces indicative of the nickel-cadmium plating.

Fatigue striations with a fairly uniform striation density of approximately 2.5 microns were clearly apparent near the terminus of the crack from SR hole "4" as well as near the termini of the fatigue cracks from SR hole "1." A P&W

metallurgist indicated that spacings between 10 and 100 microinches (0.254 to 2.54 microns) are realistic spacings expected for low-cycle fatigue cracking in the disk. Low-cycle fatigue cracking propagates from engine operation stresses that occur in flight between each engine start and shutdown (flight cycle), and one striation is created by one flight cycle.

The 0.88-inch fatigue crack outboard from SR hole "1" was the longest fatigue region at any of the SR holes. The crack lengths from each side of the hole combined with the diameter of the SR hole (0.410 inch) gave a calculated overall crack length of 1.56 inch for SR hole "1" at the time of disk separation.

The only evidence of fatigue cracking inboard from an SR hole on the recovered pieces of the 7<sup>th</sup> stage disk was that at SR hole "1."

The 12<sup>th</sup> stage HPC disk from the accident engine (which was not damaged in the accident) was examined at the P&W Metallurgical Laboratory in East Hartford, Connecticut, by P&W and Safety Board metallurgists. Several tierod holes in that disk were found with corrosion pits. Examination of a cross section through the pits confirmed that nickel and cadmium had been plated onto the pitted surfaces of these tierod holes.

Two additional engines previously owned by THY and sold to ValuJet were available for disassembly and examination of their 7<sup>th</sup> stage HPC disks by the Safety Board. Both 7<sup>th</sup> stage HPC disks appeared in serviceable condition with no plating over pitting noted.

Three other engines also previously owned by THY and sold to ValuJet had been sent by ValuJet to Air New Zealand for repair. The 7<sup>th</sup> stage HPC disks on these engines were examined by Air New Zealand engineering for the Safety Board under the supervision and control of the Civil Aviation Authority (CAA), New Zealand, and later at the P&W Metallurgical Laboratory. Each of these disks had been retired because the total time and cycles were near the hour and cycle life limit, and it would have been uneconomical to reinstall the disks and operate them for the remaining hours or cycles before they had to be removed from service. Nickel and cadmium plating over corrosion pitting in tierod and SR holes was confirmed on two of the disks, and not found on the third.

No failures of the 7<sup>th</sup> stage HPC disk on any P&W JT8D engine have been reported since 1975; however, on August 30, 1985, one failure was reported in Cameroon during taxi to takeoff. The cause was never determined because the disk fragments could not be recovered.

### 1.16.2 Burn Tests of Cabin Furnishings

The need for fire retardant cabin furnishings on transport-category aircraft was first addressed by the FAA in 1947. By 1972, FAA regulations required carpets, seats, and interior panels to undergo Bunsen burner flammability tests. Subsequently, the FAA conducted additional research and proposed upgrading these standards by adding toxicity, smoke, and improved flammability criteria.

By 1977, there were still no full-scale burn tests to support the proposed rule and standards, and the proposed rule was withdrawn. As a result, the FAA formed the Committee on Special Aviation Fire and Explosion Reduction (SAFER), which conducted full-scale tests and research and made recommendations for fire safety improvements. The technical information developed as a result of these tests provided a standardized method of evaluating the suitability of cabin materials.

On April 16, 1985, the FAA issued a notice of proposed rulemaking (NPRM) entitled "Improved Flammability Standards for Materials Used in the Interiors of Transport Category Airplane Cabins," which became a final rule in 1985. The regulation established new fire test criteria for type certification, required that the cabin interiors of airplanes manufactured after 1985 and used in air carrier service comply with these new criteria, and required that cabin interiors of all other airplanes type certified after January 1, 1958, and used in air carrier service, comply with these new criteria upon the first "general retrofit" of the cabin interior.

The accident DC-9 was manufactured before the effective date of the 1985 regulation and therefore any retrofit of fire retardant cabin furnishings was required only in the event of a "general retrofit" by the carrier. Piecemeal replacements of cabin furnishings, except for fire-blocked seat covers, are not required to meet the new flammability standards. The FAA stated that this was based on the adverse economic effect on the airline industry if the industry had to comply with the new standard. Thus, it is reasonable to expect that if an air carrier applied this regulation, as written, an airplane in service for 20 or more years might never be subjected to a "general retrofit."

On August 15, 1995, burn tests of selected pieces of cabin furnishings from accident airplane were conducted at the Fire Safety Branch of the FAA's Technical Center in **Atlantic** City, New Jersey. A relatively undamaged carpet sample, sidewall panel sample, and a seat cover that were collected from the rear of the accident airplane were tested. Testing was conducted in accordance with the standard in effect before 1985, which required the Bunsen burner flammability test. All of the components were directly exposed to the FAA's Bunsen burner test flame of 1,650 °F (1,500 °F is the minimum requirement) for 60 seconds. No ignition of the materials occurred. Thus, all of the samples met the applicable (pre-1985) FAA test requirements for flammability.

## 1.17 Additional Information

### **1.17.1 ValuJet's Purchase of Turk Hava Yollari (THY) Aircraft, Engines, and Spare Parts**

### 1.17.1.1 Pre-delivery Activities in Turkey

In July 1994, ValuJet Airlines became aware that THY had several DC-9-32 aircraft and engines for sale. ValuJet contracted with two independent consultants, who went to Turkey to evaluate the aircraft and related equipment and their records, and to provide information that would assist ValuJet in deciding whether to purchase the aircraft. After receiving input from the consultants, ValuJet decided to execute the purchase.

In September 1994, ValuJet contracted with Avionics and Aircraft Systems Engineering Services, Inc. (AAS), to provide aircraft and maintenance engineering assistance, on-site management of the aircraft delivery program, and technical publication services in connection with the acquisition and refurbishment of the THY aircraft. One of the original consultants, who was a vice president at AAS, became the primary manager of the purchase and importation process.[17](#) On October 3, 1994, a formal sales agreement was executed between ValuJet Airlines and THY for the purchase of nine aircraft, five spare engines (including the accident engine, SN 666966), and 4,400 spare parts.

Before ValuJet's acceptance of any engine or aircraft, each was subjected to a ground inspection that included the following:

- verification that all records and manuals were being delivered, and that they were complete and current,
- a borescope inspection of all mounted and spare engines,
- verification that any structural damage had been repaired in full compliance with the Aircraft DC-9 Structural Repair Manual or approved McDonnell Douglas data,
- verification of aircraft airworthiness, and currency of U.S. FAA airworthiness directives (ADs) on all aircraft,
- verification that cabin configuration changes requested by ValuJet were accomplished by THY before removing aircraft from service by Turkish Airlines,
- verification that all mounted engines were "serviceable" in accordance with P&W engine manuals,
- verification that P&W Service Bulletins 4127 (noise attenuation) and 2141 (oil dampened No. 1 bearing) had been complied with on certain engines,
- verification that the aircraft had been on a program in which the fuel tank area was inspected for corrosion and microbiological contamination, and
- inspection of the cabin for excessive wear or lack of cleanliness.

In addition, each aircraft and the engines mounted on them for their ferry flight to the United States were subjected to a regimented flight test program. According to the consultant, the test flights, which were conducted by a ValuJet-contracted pilot, and AAS representative, and a THY employee, were performed in accordance with the Douglas DC-9-32 Used Production Flight Procedures Manual.[18](#)

The sales agreement between ValuJet and THY called for five of the airplanes to be delivered with specific engines installed in specified positions. The remaining four airplanes could be delivered with any of the remaining 13 engines installed in any location. Five of the engines would then be delivered as spares.

The borescope inspection, which was conducted as part of the pre-sales agreement discussed above, found that three of the spare engines and one mounted engine needed either turbine blade or guide vane repair before they would be accepted by ValuJet. These four engines were repaired and then tested. Because a test cell was not available, some of the engines in service were removed from operating airplanes so that the repaired engines could be tested on an airplane. Thus, engine SN 666966, which was being operated in line service at the time the consultant arrived in Turkey, was removed from an airplane and became one of the five "spare" engines. According to the AAS representative, the five spare engines were subsequently preserved by THY in accordance with the P&W JT8D engine manual requirements.[19](#)

According to the sales agreement between ValuJet and THY, all spare engines were to be certified as serviceable by an FAA-certificated Part 145 repair station before acceptance by ValuJet. ValuJet and THY agreed that the spare engines would be certified as serviceable by the THY repair station and then shipped to the United States with "serviceable tags."[20](#) According to the consultant, the repair station prepared one of these tags for each spare engine. Entries on the tag for engine SN 666966 describing the work done indicated that it had been removed from an aircraft so that another

engine could be installed and that it had been preserved for up to 90 days. The consultant stated that as part of the preshipping process, he cross-checked the SN of each spare engine with its associated tag.

According to the technical control director of THY's repair station engine shop, THY intended that the statement of serviceability and release for return to service on the "serviceable tag" apply to more than just the work listed on the tag (in the case of engine SN 666966, removed from aircraft and preserved), and represented a "full" statement of serviceability. He stated that in his opinion, engine SN 666966 was able to be installed by ValuJet with no further inspections needed, except for a depreservation inspection and any in-house inspections required by ValuJet.

According to THY's technical control director, the tags that had been prepared for all five spare engines were placed into a single large brown envelope and shipped to ValuJet along with the remainder of the aircraft and engine records. The inspector stated that no tags were attached to the engines for fear that they would be lost during shipment. The spare engines were then air shipped to the United States and trucked to ValuJet's facilities in Atlanta.

The AAS consultant stated that because the aircraft had been operated by a foreign carrier, he evaluated the THY maintenance scheduling and recordkeeping system to confirm the validity of the aircraft records and conformity with FAA requirements.<sup>21</sup> As part of this process, AAS reviewed all entries in the Aircraft Maintenance Log of each airplane for the last 2 years, or since the last "D" check, whichever came last. AAS also reviewed the records of all mounted engines, spare engines, and major components for the last 2 years, or since the last overhaul. During this review, any entries that could not be accurately determined were translated into English. In addition, other applicable records, such as FAA Forms 337 (Major Repair or Alteration), AD and engine disk status records, and certain shop records associated with the repair of spare parts, were translated into English.

According to the AAS representative, during this process, he reviewed the records to verify a history of compliance, and compared compliance statements recorded in the maintenance records to process documents executed at the time of the compliance action. As part of this process, and in accordance with the guidance provided in FAA Order 8300.10, the accuracy of AD compliance records was verified by spot checks of the aircraft. According to the AAS representative, all requested documentation was provided, and he determined that the recordkeeping system was valid.

The consultant also confirmed that the THY aircraft had been maintained in accordance with the following documents/programs: McDonnell Douglas Aircraft Maintenance Planning Document, DC-9/MD-80 Corrosion Prevention and Control Document, DC-9/MD-80 Aging Aircraft Service Requirements Documents, and DC-9/MD-80 Life Limited Parts Document. At the time of the purchase, these documents/programs were being used to maintain DC-9 aircraft already operating in the ValuJet Airlines fleet; and these documents/programs became the basis for phasing the THY aircraft into the ValuJet maintenance program.

When all pre-acceptance inspections were completed on an aircraft, it was deregistered in Turkey<sup>22</sup> and issued a "Certificate of Airworthiness For Export" by the Republic of Turkey Ministry of Transport and Communications. Each aircraft was then issued an FAA Temporary Registration and an FAA Ferry/Environmental Permit by the ValuJet FAA principal maintenance inspector (PMI). Each of the nine aircraft was then flown to Lake City Municipal Airport, Lake City, Florida, where Aero Corporation began the process necessary for the aircraft's return to service in the United States.

### 1.17.1.2 Post-delivery Activities in the United States

A designated airworthiness representative (DAR) was contracted by ValuJet's consultant to issue the U.S. Standard Airworthiness Certificate for the nine aircraft. The DAR had no involvement with the inspection, acceptance, delivery, or return to service of the five spare engines and the approximately 4,400 spare parts purchased by ValuJet.[23](#)

While at ValuJet's facility in Atlanta, engine SN 666966 was stored inside but did not undergo humidity inspections at 30-day intervals as required by the P&W engine manual. According to ValuJet's Manager of Engineering, the inspections were not performed because ValuJet's general maintenance manual at the time did not include specific instructions for conducting humidity inspections of stored engines. Since this accident, stored-engine inspection procedures, consistent with P&W's instructions, have been incorporated into ValuJet's powerplant and maintenance specifications.

Engine SN 666966 was subsequently shipped to the Aero Thrust Corporation in Miami, Florida, where P&W Service Bulletin 4127 (installation of noise attenuation equipment) was complied with on January 21, 1995. The engine was then shipped to the Dee Howard Corporation in San Antonio, Texas, on January 27, 1995, for installation on an aircraft.

According to the receiving and tagging instructions contained in ValuJet's general maintenance manual, when a serial-numbered component is received by ValuJet, the component is to be tagged with the company's equipment transfer record (ETR). Applicable information regarding the item's serviceability from the vendor's tag or manufacturer's certification is transferred to the ETR, and copies of the ETR, along with the original vendor's tag, are forwarded to ValuJet's Aircraft Records Department. One copy of the ETR remains attached to the component, and installation and removal data are entered on this record when the component is installed on an aircraft.

According to ValuJet's general maintenance manual, Dee Howard's inspection procedures manual, and the aircraft maintenance agreement between ValuJet and Dee Howard, engine SN 666966 should have been shipped to Dee Howard with a partially executed ETR attached. The serviceable component tag would remain in ValuJet's Aircraft Records Department. The engine could then be installed by Dee Howard based upon the certification of airworthiness inherent in the signature in block #10 of the ETR. However, according to Dee Howard's manager of quality assurance, engine SN 666966 arrived at Dee Howard without a ValuJet ETR or a vendor's tag from THY. The only document that arrived with the engine was the "Partial Repair Item" tag executed by AeroThrust Corporation during the completion of P&W Service Bulletin 4127 (installation of noise attenuation equipment).

According to the manager of Dee Howard's quality assurance, because the engine arrived without documentation of its serviceability, Dee Howard requested that the on-site ValuJet quality control inspector provide certification for the engine. Dee Howard was informed by this inspector that a serviceable component tag had been issued by an FAA Part 145 foreign repair station. The ValuJet quality control inspector on site (at Dee Howard) then executed ETR #14419 certifying the airworthiness of the engine. The investigation revealed that he did not review engine records or a serviceable tag before doing so.

On February 9, 1995, after 106 days in preservation, engine SN 666966 was removed from preservation to be installed in the No. 2 (right) position on N908VJ, the accident airplane, on March 5, 1995. The engine and airplane were subsequently operated by ValuJet until the accident on June 8, 1995.



### 1.17.2 1991 Overhaul/Inspection of 7<sup>th</sup> Stage HPC Disk by THY

Maintenance records obtained from ValuJet indicated that the 7<sup>th</sup> stage HPC disk had been overhauled by THY during the time period from March 1991 to August 1991, and that the disk had accumulated 18,477 hours and 11,907 cycles at that time. The records obtained from ValuJet pertaining to the 1991 overhaul were limited to build records<sup>24</sup> and logbooks documenting the times and cycles of the engine, including the accident disk. However, no records were found documenting each step of the overhaul of each individual disk, including what kind of an inspection was performed on the 7<sup>th</sup> stage disk.<sup>25</sup> (See appendix C for an example of this sort of documentation, typically used in the industry.) THY personnel stated that all of the records that pertained to the airplanes and engines purchased by ValuJet were transferred to ValuJet.

The Director of THY's overhaul shop<sup>26</sup> stated in a meeting with Safety Board staff that the repair facility had performed a magnetic particle inspection (MPI)<sup>27</sup> on the disk but during that time had only inspected the tierod holes, not the SR holes, because the P&W engine manual only required the tierod holes to be inspected. (See section 1.17.3 for more discussion on this.)

In response to the Safety Board's inquiry about whether THY's repair facility had documented each step of the inspection and overhaul process, the Director of THY's overhaul shop provided the Safety Board, as a sample, a small card (slightly larger than a 3" by 5" card) that had been used during the overhaul of a disk in 1995. The card had part identification and operation data on one side, and handwritten notes about the repairs that had been done on the other side. The card listed repairs for removing and replacing the nickel cadmium plating; however, it did not list fluorescent magnetic particle inspection (FMPI),<sup>28</sup> which is a required inspection during disk overhaul, according to the P&W JT8D engine manual (see next section of this report). The type of card displayed by the Director of THY's overhaul shop was not found in any engine record package for the failed engine.

In a letter to Safety Board staff dated June 18, 1996, the Director of THY's overhaul shop stated that an FMPI inspection had been used in July 1991 to inspect the 7<sup>th</sup> stage HPC disks in JT8D engines. He stated that Turkish Airlines has had FMPI capability since the early 1970s and improved the capability in 1978 and 1985.

He further stated that per Turkish Airlines' procedures in 1991, nickel cadmium plating would not have been removed from a JT8D HPC disk if there were 0.003-inch (or less) deep corrosion pits on the surface of the disk, provided such pits were not located in the tierod/pin holes, the bore area, and/or snap diameters. He further stated that it was necessary, in July 1991, to inspect for and remove surface corrosion pits from within the SR holes only if their depth was over 0.003 inch, based on the fact that the P&W engine manual did not list SR holes as a critical inspection area and "it did not even show them in Figures 801 and 802 of the referenced section, until subject section of the Manual was revised after June 1995."

### 1.17.3 Pratt & Whitney Guidance On Engine Overhaul/Inspection

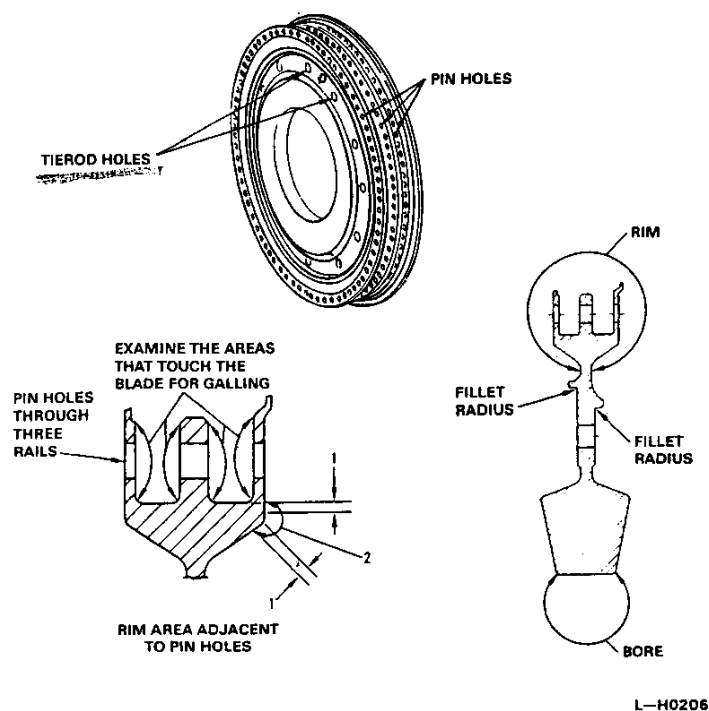
The 7<sup>th</sup> stage compressor disk inspection instructions from the P&W JT8D Engine Manual, Section 72-36-41, revision dated February 1, 1991, state that the following disk features must be inspected very carefully: bore, tierod holes, snap diameter (front and rear) fillet radius, pin holes, areas on the rim that touch blades, and for very early disks, balance flanges and balance flange rivet holes. Graphic illustrations in the instructions (listed as figure 801 in the P&W instructions) show the various features of the disk that were named in the text. [\(See figure 7.\)](#)

The P&W engine manual specifies that for area 7 of the P&W figure 802 (see appendix D), which is depicted as a tierod hole, no unrepaired damage can be allowed in any hole, or within 0.125 inch of the edge of the hole on adjacent surfaces, and that damage can be repaired to a depth of 0.005 inch by blending. The instructions further indicate that damage up to 0.003 inch is acceptable in the web area of the disk without blending. The cross-section of the 7<sup>th</sup> stage disk in P&W figure 802 depicts the tierod holes, but does not have the hidden lines, [29](#) which would depict the smaller diameter SR holes behind the tierod holes, or a separate cross-section of the disk, just through the SR holes.

P&W JT8D Engine Manual Section 72-36-41, lists steps for overhauling the 7<sup>th</sup> stage HPC disk (see appendix D) (steps that are incorporated onto "process sheets" or similar documentation provided by airlines and Part 145 repair stations). The following summarizes the overhaul steps:

1. Measure and record front and rear snap diameters, tierod hole centerline in relation to rear snap diameter, and web thickness in area contacted by spacers.
2. Strip existing nickel-cadmium plate.
3. Remove any residual rust after stripping nickel-cadmium.
4. Dimensionally inspect after removing old nickel-cadmium plate and any previous plating repairs, measure front and rear snap diameters and tierod holes.
5. Visually inspect all areas of each disk for pitting, galling, and other defects.
6. Magnetic particle inspect per Task 72-36-00-24-000, Section 72-36-00, Inspection 02. [This section and inspection refers to fluorescent magnetic particle inspection.] Note: Inspection is necessary after stripping even though disk may have been inspected previously.
7. Make all necessary blending and machining repairs prior to plating.
8. Mask areas not to be plated leaving areas exposed that require restoration or new plating.
9. Nickel plate areas not masked.
10. Machine nickel plated areas as required.
11. Nickel-cadmium plate entire disk.

**Pratt & Whitney**  
**JT8D ENGINE MANUAL (PN 481672 - RESTRUCTURED)**  
**COMPRESSOR DISK, STAGE 7 - INSPECTION-01**



1. 0.125 Inch Maximum.
2. Electrical Contact Permissible Only In This Area. No Burning, Pitting, or Selective Attack Permitted.

R  
R

Important Inspection And  
 Electrical Contact Areas  
 Figure 801  
 (Task 72-36-41-22-000)

EFF: -ALL

**72-36-41**

INSP-01  
 Page 803  
 FEB 1/93  
 000

**Figure 7—P&W JT8D Engine Manual—Compressor disk, stage 7 - Inspection 01**

#### 1.17.4 FAA Regulations Regarding The Return To Service Of The Spare Engines

Federal regulations require that the following specific information be entered in the maintenance record of any item on which work has been performed: a description of the work performed; the date the work was completed; the name of the person who performed the work; and the signature, certificate number, and kind of certificate held by the person who approved the work. The signature constitutes the approval for return to service only for the work performed, and this maintenance record entry must be made before any person can return an engine to service.

The regulations further state that the holder of a repair station certificate may approve an aircraft, airframe, engine...for return to service.<sup>30</sup> The regulations also provide that before an engine can be returned to service it must have been inspected by a qualified inspector and that the maintenance facility must certify in the maintenance record that it is airworthy with respect to the maintenance performed. The qualified inspector must be an individual who has shown by experience as a journeyman that he or she understands the inspection methods, techniques, and equipment used in determining the airworthiness of the article concerned.<sup>31</sup>

Common industry practice is to include the following statement, or words to this effect, on the serviceable tag:<sup>32</sup>

The aircraft, airframe, aircraft engine, propeller, or appliance identified above was repaired and inspected in accordance with current FAA regulations, and is approved for return to service. Pertinent details of the repair are on file at this repair station under Order No. \_\_\_\_

FAA Advisory Circular 145-3 (Guide for Developing and Evaluating Repair Station Inspection Procedure Manuals (IPMs)) Appendix F, Figure 34 (Final Inspection and Release to Service) provides this sample language for a repair station IPM: "Aircraft components, appliances, and other items, other than complete aircraft, repaired or overhauled as authorized by the repair station specifications, will be returned to service through the use of a maintenance release preprinted on the serviceable parts tag described by this section of the manual."

With respect to the scope of work authorized by foreign repair stations, the regulations state that a certified repair station may, with respect to U.S.-registered aircraft, maintain or alter aircraft, airframes, powerplants, propellers, or component parts. The regulations further state that after major repair or alteration, a certified repair station (domestic or foreign) can return to service only articles that have been worked on according to technical data approved by the FAA Administrator.<sup>33</sup>

Federal regulations require that domestic repair stations keep records of work performed for at least 2 years; foreign repair stations are exempt from these recordkeeping requirements.<sup>34</sup> However, foreign repair stations are required to keep records of maintenance performed on U.S.-registered aircraft containing basic details and whatever additional information the FAA Administrator finds necessary regarding U.S.-registered aircraft.<sup>35</sup> The regulations do not specify how long such records must be kept. However, the FAA generally specifies a time period in the repair station's inspection procedures manual.

FAA Order 8130.2C (Airworthiness certification of aircraft and related products) Section 3 (aircraft engines, propellers, materials, parts and appliances), paragraph 220, states that the person who returns an imported product to service (in accordance with 14 CFR Part 43.5) must ensure that the product:

- has not been modified, changed, or damaged subsequent to the time of export certification;
- complies with all FAA ADs;
- is installed in accordance with FAA-approved design data;
- is found to be in condition for safe operation; and
- is accompanied by the necessary maintenance documentation.

### 1.17.5 THY Repair Station

THY operates a repair station that is certified by both the FAA and the Director General of Civil Aviation (DGCA) in Turkey. The repair station maintains and overhauls airplanes that are part of the Turkish Airlines fleet as well as airplanes and engines operated by foreign and domestic operators. Authority granted by the Turkish DGCA allows the repair station to overhaul JT8D engines for the THY fleet. THY receives its authority to overhaul JT8D engines for U.S.-registered airlines from the FAA.

According to its FAA Air Agency Certificate, first issued in 1974, and its Repair Station Operations Specifications, which are periodically reissued and revised by the FAA, THY has been an FAA-certificated 14 CFR Part 145 Subpart C repair station since March 8, 1974, with the following ratings: airframe, powerplant, instrument, accessory, radio, and limited specialized service. Before 1986, its operations specification limitations listed Airframe Class 4 (all-metal large aircraft) and Powerplant Class 3 (turbine engines), without further limitation to specific airframes or engines.

The revised operations specification issued on November 21, 1986,<sup>36</sup> listed "Limited Ratings"<sup>37</sup> for Airframe to include: Airbus Industries A300 and A310 series, Boeing B707/720, and B727 series, Fokker F28 series, McDonnell Douglas DC-9 and DC-10 series, and other airplanes; and for Powerplant to include: General Electric CF6 series, P&W JT3D, JT8D, JT9D, and PT6A series, and various Rolls Royce engines. A note under the powerplant limited ratings stated the following:

LINE MAINTENANCE FOR OTHER ENGINES IN THE CLASS 3 CATEGORY. AUTHORIZATION IS LIMITED TO MINOR INSPECTIONS, REMOVAL/ INSTALLATION OF ACCESSORIES AND COMPONENTS, ADJUSTMENTS, MINOR REPAIRS, MINOR ALTERATIONS ONLY. WORK TO BE ACCOMPLISHED IN ACCORDANCE WITH THE MANUFACTURER'S TECHNICAL DATA OR OTHER PROCEDURES ACCEPTABLE TO THE [FAA] ADMINISTRATOR.

The Safety Board was unable to obtain the THY Repair Station Operations Specifications that were applicable between November 1989 and October 1991. The Board did examine the operations specifications in force for the period ending November 23, 1989, and the period beginning October 29, 1991. Both of those operations specifications included limited ratings for P&W JT8D and other engines and contained the same note, quoted above: "Line maintenance for other engines in the Class 3 category. Authorization is limited to minor inspections...."

The statement addressing line maintenance of other engines in the Class 3 category remained unchanged until August 4, 1994, when the entire note under powerplant limited ratings was revised to read:

POWERPLANT AUTHORIZATION FOR THE AFOREMENTIONED ENGINES INCLUDES MAINTENANCE AT ALL LEVELS UP TO AND INCLUDING OVERHAUL IN ACCORDANCE WITH CURRENT MANUFACTURER'S MAINTENANCE MANUALS OR OTHER FAA APPROVED DATA. MAINTENANCE (EXCLUDING OVERHAUL) IS LIMITED TO ENGINES INSTALLED ON AIRCRAFT LISTED IN THE AIRFRAME RATINGS AND FURTHER LIMITED TO THOSE MAINTENANCE FUNCTIONS AS AUTHORIZED BY THE CURRENT MANUFACTURER'S MAINTENANCE OR FAA APPROVED DATA.

Under "Specialized Service," the October 29, 1991, Repair Station Operations Specifications listed the following nondestructive testing methods: ultrasonic; magnetic particle per MIL-I-25135 and MIL-SAD-6868, as revised; eddy current per MIL-SAD-1537A, as revised; penetrant-visible dye and fluorescent dye per MIL-SAD-6866, as revised; and radiographic x-ray per MIL-SAD-453C, as revised.

THY maintains that it was authorized by the Turkish DGCA to operate a turbine-engine repair station and to overhaul P&W JT8D and other engines. However, THY maintained that it "...clearly understood from operations specifications of Turkish Airlines that THY [was] authorized to make any kind of repair and overhaul of JT8D engines. Turkish Airlines repair/overhaul certification for JT8D engines has never been discontinued between 1974 and 1996."

Following the accident, by memorandum dated November 16, 1995, the Safety Board was advised by the FAA's Director of Flight Standards Service (AFS-1) that the THY repair station had not been decertified at any time since the 1974 issuance of its original repair station certificate. However, he reported that THY's Class 3 powerplant rating had been changed to limited powerplant, excluding overhaul, on November 21, 1986, and that the FAA's "files do not contain any information relative to this change other than the certificates themselves." AFS-1 reported that THY was again authorized to overhaul JT8D engines on August 4, 1994.

The PMI who was assigned surveillance responsibilities at THY from 1992 to 1995 stated that although THY retained the capability to conduct JT8D overhauls after 1986, THY had no need for FAA-granted overhaul authority from the FAA until 1994, because of inactivity involving U.S.-registered airplanes. Reauthorization of foreign operations specifications was, at that time, dependent on annual activity in support of U.S.-registered airplanes. He stated that he was confident that THY understood its 1986-1994 limitation because he received a phone call from THY in 1994 requesting that THY's FAA repair station authority be expanded to include overhauls on various engines.

According to the PMI, the PMI, along with a three-man team, subsequently conducted a 3-day inspection that resulted in the amended THY repair station operations specifications dated August 4, 1994, which authorized overhauls of CF6, JT3D, JT8D, JT9D, and PT6A series engines. The amended operations specifications also added D-check authorizations for Airbus Industries A310, A340, Boeing 707/720, 727, 737, Fokker F28, McDonnell Douglas DC-9 and DC-10, and other airplanes.

THY maintains that the FAA never informed it of any change to its authority to overhaul JT8D or other engines and that THY has never requested such a change to its operations specifications. THY reported to the Safety Board that it has always maintained and overhauled P&W engines in accordance with manufacturer maintenance and overhaul manuals and standards and that this is also a requirement for certification as a repair station by the Turkish DGCA.

### 1.17.5.1 Pratt & Whitney Engine Shop Maintenance Review

During the investigation, the Safety Board discovered that P&W engineering personnel had conducted a Turkish Airlines JT8D Engine Shop Maintenance Review in December 1991. THY provided a copy of the review to the Safety Board. The report noted that the THY shop had been set up to handle a maximum of 50 JT8D shop visits per year and that it was averaging approximately 35 shop visits per year. The P&W review contained conclusions/recommendations, including the following:

- Conclusion: Turkish Airlines' shop personnel are experienced and know the procedures for cleaning, stripping, plating, and other repairs; however, new personnel sometimes enter the shop, and procedures are sometimes revised. Because the Engine Manual is written in English and presents a generic view of each procedure, Turkish Airlines should prepare process sheets that 1) describe the specific processes and repair procedures in Turkish, 2) describe actual shop equipment used at Turkish Airlines, and 3) require shop personnel to sign each significant step of the procedure as that procedure is completed. Process sheets will help avoid many repair problems and will confirm that the complete, up-to-date procedure has been accomplished. These sheets can also be used in a computerized parts tracking system.
- Recommendation: Prepare specific, Turkish-language process sheets for parts sent into the shop.
- Conclusion: Many of the parts racks are dirty. Clean parts can become dirty enroute to the FPI [fluorescent particle inspection]/FMPI area, which can lead to contamination of the expensive FPI penetrants.
- Recommendation: Periodically steam clean the parts racks.
- Conclusion: The job card that routes the parts through FPI and FMPI does not specify the process or have a sign-off line for the inspectors to see that the work has been done. The only indication that the parts have been FPI inspected is a green wire attached to the parts. Several parts were found with green wires attached without any evidence of background fluorescence that is typical of parts that have been processed through the FPI line.
- Recommendation: Specify the FPI or FMPI SPOP on the work order with a sign-off line for the inspector to permit the inspection process to be verified and the inspector for that part to be identified.

### 1.17.5.2 FAA Inspections of THY Repair Station

The Safety Board staff reviewed FAA Program Tracking and Reporting System (PTRS) records and correspondence between the FAA and THY to determine the frequency and level of FAA oversight of the THY repair station. The PTRS records, which were only available from June 1993 to the present, typically reflected one to three visits per year with mostly favorable but some adverse comments that required corrective action. These records were not as detailed as the 1991 P&W JT8D Engine Shop Maintenance Review, but included checklists and indicated relatively comprehensive inspections of the facility.

Additional correspondence pertaining to FAA oversight and recertification of THY addressed the periodic renewals of the THY Air Agency Certificate and Repair Station Operations Specifications and provided the results of FAA inspections in connection with those renewals. The Safety Board found that the renewals followed FAA inspections of the THY facility after 1- or 2-year intervals. The FAA required correction of the listed inspection discrepancies in advance of reissuance of repair station certificates. For example, in its September 5, 1991, letter to THY, the FAA PMI advised the repair station:

Turkish Airlines NDT [non-destructive testing] area must be audited by the company and new procedures implemented. Calibration of black lights and calibration meter must have records of calibration by Mil-Std. Also X-ray must have a means of checking the film after X-ray by use of the penetrameters or by using a densitometer to measure density. This office recommends the supervisor of the NDT shop receive addition[al] factory training in all areas of NDT to update personnel assigned. Eye examination per Mil-Std-410 are (sic) required for all NDT personnel. Corrective action of these discrepancies was required within 60 days and, according to FAA correspondence, was accomplished by THY in advance of the reauthorization of the operations specifications, which occurred on October 29, 1991.

The FAA PMI with oversight responsibility for THY from 1992-1995 stated that renewals were sometimes extended to 2-year intervals because of FAA staffing shortages; he reported that in 1992, his office (International Field Office, Frankfurt, Germany) had only six persons to inspect, certify, and surveil all of the Part 145 Repair Stations in Europe; as the number of such stations grew, his office grew to its 1995 staffing level of 20 inspectors. He stated that he was personally responsible for 21 repair stations in 1992.

The FAA correspondence indicated that reauthorization of the operations specifications was in part dependent on annual activity in support of U.S.-registered airplanes. The application dated August 31, 1991, stated that the specifications were to be reauthorized despite no such work in the previous 3 years. The correspondence indicated that the THY repair station activity involving U.S.-registered airplanes was quite limited in other years as well, although contracts with two U.S. air carriers have increased that activity since 1992.

A four-person FAA team performed an inspection of the THY repair station from June 27 through 29, 1995. This inspection, which, according to the FAA, had been planned before the accident, was to recertify Turkish Airlines' Part 145 repair station certificate. As a result of the accident, the team assigned two personnel to focus on areas relating to the accident investigation. A memorandum documenting the inspection indicated that the inspection team included the PMI, another maintenance inspector, an avionics inspector, and an engineer from the Aircraft Certification Office in Brussels, Belgium.

According to the memorandum, the inspection team focused on two issues: (1) FAA recertification of THY's Part 145 certificate, and (2) information regarding turbine engine maintenance. The memorandum stated that based on the audit reports of the engineer and one of the maintenance inspectors, it appeared that the repair station's methods, techniques, and practices were satisfactory at the time of the inspection.

In the maintenance inspector's report, which was attached to the memorandum, the inspector commented about THY's compressor disk repair capabilities. He stated that the correct P&W maintenance manual was available and that the disk repair procedures used were P&W's instructions. According to the inspector's report, the technicians could read and speak English and were familiar with the process for corrosion identification and removal. The work station in the visual inspection area was reported to be well lighted and the tools for blending surface damage were appropriate. The report also stated that in the plating shop, the procedures were available in both English and Turkish.

The engineer's report, which was also attached to the memorandum, indicated that THY overhauled its own engine compressor disks after a maximum of 4 years, compared with the FAA Airworthiness Directive (AD) 94-20-01 requirement for overhaul at a maximum of 10 years. According to the report, this action was taken because THY had purposely left a plated tiebolt, of the same material and plating as a disk, outside for 1 year and found that it developed corrosion under the plating.

One of the inspectors' reports attached to the memorandum stated that none of the overhaul records for the failed engine were available at THY at the time of the FAA inspection.



### 1.17.6 ValuJet's Flight Attendant Training Program

Federal regulations<sup>38</sup> require that certain emergency drills be conducted by crewmembers, including flight crewmembers, during initial training and recurrent training at 24-month intervals. The regulations state, in part, that crewmembers shall perform emergency exit drills, operating each type of emergency exit in both normal and emergency modes and that the drills shall replicate the actions and forces required in the deployment of the emergency evacuation slides.

FAA Air Carrier Operations Bulletin (ACOB) 8-76-6, "Guidelines for Crewmember Training on Aircraft Tailcones and Approval of Tailcone Training Devices," dated July 13, 1992, allowed air carriers to train their DC-9/MD-80 crewmembers by having an instructor or trainee operate the tailcone release handle while other trainees observed. ACOB 8-76-6 was current at the time that ValuJet was certificated on October 21, 1993, and it was current on August 30, 1995, when the FAA was queried by Safety Board investigators regarding the ACOB's status.

On January 26, 1996, the FAA issued Flight Standards Handbook Bulletin 96-02, "Guidelines for Crewmember Training on Aircraft Tailcones and Approval of Tailcone Training Devices." This bulletin set forth acceptable means of approving tailcone training devices and required that each trainee actually operate the appropriate mechanisms to ensure evacuation through the tailcone exit.

ValuJet Airlines' flight attendant training program, which included crewmember exit drills, was approved by the FAA in a letter dated September 23, 1993, to ValuJet's Vice President of Marketing. ValuJet's flight attendant training syllabus in effect at the time of the accident, and which also was approved by the FAA, did not address tailcone exit drills. However, ValuJet's Manager of Inflight Training stated that exit drills were conducted on an actual airplane, during which crewmembers simulated pulling the tailcone release handle, rather than actually operating the tailcone exit. Additionally, passenger entry door and service door training was conducted on ValuJet airplanes, during which bungee chords were attached to the doors to simulate the forces of the emergency evacuation slide being pulled from its bustle. According to ValuJet, pilots participated in the same drills as the flight attendants. After this accident, ValuJet acquired a tailcone exit training device and trained all active flight attendants with the use of this device by the end of August 1995.

Several errors in ValuJet's DC-9 flight attendant manual were noted by Safety Board investigators. For example, although the correct operation of the tailcone exit was described, an illustration for an MD-80 aft entrance door was used rather than an illustration for the DC-9-32 airplane operated by ValuJet. Also, a diagram for the tailcone interior jettison handle stated "Note Tailcone is normally jettisoned using the passenger aft entrance door emergency handle." This referred to MD-80 aircraft and not the DC-9-32 airplane. Another diagram depicted ValuJet's airplanes as having both a tailcone exit door and an exit hatch, although ValuJet does not operate any DC-9 aircraft with a hatch.

The flight attendant manual also contained incorrect information, or lack of information, regarding flight attendant flotation equipment, passenger safety announcements, flight attendant operation of the cabin emergency lighting switch, and use of the water fire extinguisher. The Manager of Inflight Training, who was hired in March 1995, stated that the flight attendant manual was in the process of being revised at the time of the accident. ValuJet issued a new flight attendant manual on November 11, 1995. (See Appendix F.) The new manual does not contain the errors found in the previous version.

### 1.17.7 Safety Board Recommendations Subsequent to the Accident

Following the accident, on July 6, 1995, the Safety Board issued three safety recommendations to the FAA regarding the failure of the accident engine, the wording of P&W repair guidance, and FAA guidance to maintenance personnel. The Safety Board stated in its recommendation letter that the metallurgical examination of the 7<sup>th</sup> stage HPC disk from the ValuJet engine showed that the failure was caused by fatigue cracking that had originated at a corrosion pit in an SR hole. The letter stated that there was evidence that the corrosion pit had been plated over during an overhaul of the disk in 1991, and that, additionally, it appeared that the size of the corrosion pit exceeded the allowable limits at the time of the overhaul.

The letter further stated that examination of the fatigue crack revealed a minimum of 7,000 to 8,000 fatigue striations. The letter concluded that, assuming that each striation represented one "flight cycle," based on the 4,433 flight cycles accumulated since the last inspection, the crack would probably have been detectable by non-destructive testing or by visual inspection at the time that the engine was last overhauled.

As a result, the Safety Board issued the following urgent Safety Recommendation A-95-71 to the FAA:

Issue an Airworthiness Directive to require the inspection of Pratt & Whitney JT8D engine high pressure compressor steel disks that were last overhauled and maintained by Turk Hava Yollari of Turkey prior to reaching 3,000 cycles since that last overhaul and inspection. Special attention should be given to the potential for corrosion pitting or cracks in the shielding [SR] holes in 7<sup>th</sup> stage high pressure compressor disks.

On September 14, 1995, the FAA reported that on July 10, 1995, a Telegraphic Airworthiness Directive (AD), T95-15-51, was issued that was applicable to certain P&W JT8D engines containing HPCs that had been inspected by THY. The AD required that those engines containing any 7<sup>th</sup> through 12<sup>th</sup> stage HPC disks that had accumulated 2,900 or more cycles on the effective date of the AD or 100 cycles in service after the effective date of the AD, whichever occurred first, be inspected in accordance with the P&W JT8D engine manual for evidence of corrosion pitting and cracks. According to P&W, no cracks were found in any of the inspected disks. The Safety Board responded that the action satisfied the intent of the recommendation, which was then classified "Closed--Acceptable Action."

The Safety Board also stated in its recommendation letter that it noted that P&W engine manuals provided overhaul facilities with inspection guidance, allowable limits for damage, and repair procedures. The Safety Board stated that the inspection material was quite detailed but that it could be difficult to understand. It was noted that such misunderstandings could be magnified when translating the instructions from English into another language. Consequently, the Safety Board issued Safety Recommendation A-95-72, asking the FAA to:

Modify the wording of the inspection and damage limits provided in the Pratt & Whitney manuals and service bulletins for JT8D high pressure compressor steel disks to prevent any misunderstanding of the amount of damage allowed and the procedures required for the repair and return to service of the disks.

On September 14, 1995, the FAA reported that it was working with P&W to modify the engine manual as requested. On November 20, 1995, the Safety Board classified this recommendation "Open--Acceptable Response." By letter dated June 4, 1996, the FAA reported that the JT8D engine manual was revised to clarify the amount of damage that is allowed and the procedures required for the repair and return to service of the disks.

However, the Safety Board has noted that the revised inspection sections for the 10<sup>th</sup>, 11<sup>th</sup>, and 12<sup>th</sup> stage HPC disks incorrectly show those disks as having SR holes. In addition, the inspection section for the 13<sup>th</sup> stage HPC disk, which is made of a non-magnetic nickel alloy, was revised to add an FMPI, which would only be appropriate for parts made of alloys that can be magnetized. Consequently, pending further modifications of the JT8D engine manual to correct these inaccuracies, Safety Recommendation A-95-72 remains in an "Open--Acceptable Response" status.

The Board also issued Safety Recommendation A-95-73, which asked the FAA to:

Provide additional guidance to designated airworthiness representatives and aviation maintenance personnel to ascertain whether facilities that have repaired or overhauled aircraft, aircraft engines, and aircraft equipment submitted for acceptance in the United States held the proper Federal Aviation Administration certificates at the time the work was accomplished. In either event, the guidance should include the actions to be taken to ensure compliance with the Federal Aviation Regulations.

On September 14, 1995, the FAA reported that a flight standards information bulletin (FSIB) would be issued. The FSIB would remind FAA inspectors and designees of their responsibility to ensure that aircraft, aircraft engines, propellers, and other parts imported or accepted into the United States meet the requirements of the FAA regulations and follow established FAA policy and guidance. The FAA subsequently issued FSIB for Airworthiness (FSAW) 96-14, effective July 5, 1996. The Safety Board found the FSAW responsive to the intent of Safety Recommendation A-95-73, and the recommendation has been classified "Closed--Acceptable Action."



## 2. Analysis

## 2.1 General

The flightcrew was properly certified and trained for the flight, and was in compliance with the Federal regulations on flight and duty time. The flight attendants had completed ValuJet's FAA approved flight attendant training program in existence at the time of the accident. The airplane was properly certificated and operated in accordance with applicable Federal regulations. The aircraft certification process followed by the DAR was thorough and complete in that all required aircraft and record inspections were performed. The DAR's airplane certification process was not considered relevant to the accident sequence. Visual meteorological conditions prevailed, and weather was not a factor in the accident.

## 2.2 Uncontained Engine Failure

An uncontained failure of the right engine occurred at low speed, early in the takeoff roll. The rapid decrease in the EPR of the right engine recorded on the DFDR was the result of the uncontained failure of the right engine. As a result of the uncontained failure, engine shrapnel penetrated the fuselage, severing the right engine main fuel line. Pressurized fuel sprayed into the cabin near the aft lavatory and was most likely ignited by sparks generated by steel engine fragments contacting steel galley equipment in the cabin.

Postaccident examination of the failed right engine revealed that the 7<sup>th</sup> stage HPC disk was fractured. Metallurgical examination of the two major pieces of the disk that were recovered revealed fatigue cracking in the SR hole "1" location in the larger piece of the 7<sup>th</sup> stage disk. The combined fatigue crack lengths and hole diameter accounted for an overall crack length of 1.56 inches at SR hole "1." Also, the crack at SR hole "1" contained the largest outboard propagating fatigue crack and the only inboard propagating fatigue crack found on the disk. This combined fatigue crack length is consistent with a critical crack length expected to produce separation of the disk under normal operating conditions. Also, because this fatigue crack was the only one on a radial fracture plane that went completely through the section between the bore and rim, it was likely the primary fracture initiation area.

Although the fracture was heavily damaged, analysis of fatigue striation measurements in the outboard fatigue region from SR hole "1" indicated that a crack of about 12 mm (approximately 1/2 inch) existed in the disk at the last reported overhaul in 1991, or 4,430 engine cycles before the disk failure.<sup>39</sup> Thus, the Safety Board concludes that a detectable crack<sup>40</sup> existed in an SR hole in the 7<sup>th</sup> stage HPC disk of engine SN 666966 when the disk was overhauled by THY in 1991, and therefore detectable by FMPI or MPI.

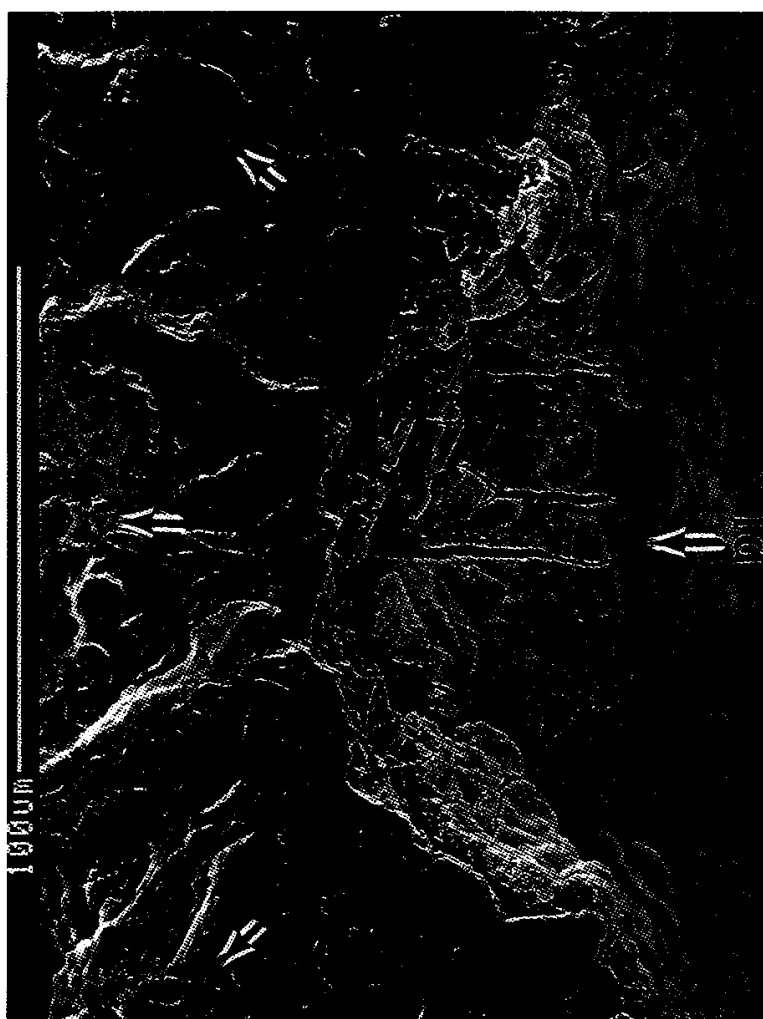
Fatigue crack initiation at SR hole "1" and others was linked to corrosion pits, some as deep as .003 inch, in the SR holes that were shown to be plated over with nickel cadmium. Although the investigation could not determine when the pits were plated over, the plating over of the pits indicates that they existed in the disk during the overhaul inspection by THY in 1991, as that would have been the last time before the accident that the disk would have been off the engine. Plating over pitted surfaces also existed in several tiebolt holes on the 12<sup>th</sup> stage disk of the accident engine.

## 2.3 Overhaul Procedures by Thy

The size of the fatigue crack and the plating over corrosion pits in the SR holes indicate that during the overhaul of the 7<sup>th</sup> stage disk by THY in 1991, a proper inspection was not performed. The Director of THY's overhaul shop initially contended that because the P&W engine manual did not specifically refer to the SR holes, only the tierod holes needed to be addressed in the overhaul inspection. Later in the investigation, the Director indicated that an inspection<sup>41</sup> of the SR holes had been performed but to a different standard than that for the tierod holes—one that permitted scattered surface damage up to 0.003-inch deep to go unrepaired.

If the THY repair station did perform an inspection of the disk, including the SR hole "1," but did not repair the damage or reject the part because the damage was limited to corrosion pits of 0.003 inch or less as the Director of the THY overhaul shop contends, this raises some concerns. First, the P&W engine manual states that no unrepaired surface damage is allowed in any hole or within 0.125 inch of the edge of a hole on adjacent surfaces. If THY was uncertain about how this statement applied to the SR holes, THY should have discussed this with P&W technical representatives to clarify any uncertainties.

More importantly, however, a properly performed inspection should have detected a crack estimated to be 1/2-inch long at the time of the THY overhaul in 1991. During an MPI inspection, the entire disk is magnetized, and magnetic particles are applied to the disk. The SR holes would inescapably be included in this type of inspection because of their proximity to the tierod holes, and the 1/2-inch crack would have been readily visible, not only inside the SR hole, but along the surface of the disk. During an FMPI inspection, the entire disk is not only magnetized, but is also covered in a solution containing fluorescent iron particles that would further highlight any defects. Accordingly, the Safety Board concludes that THY did not perform a proper inspection when the disk was overhauled in 1991. Had the THY repair station accomplished a proper inspection of the 7<sup>th</sup> stage high compressor disk of engine SN 666966, the crack would probably have been detected, the part rejected, and consequently, the accident may have been avoided.



**Figure 8--High-magnification view of a pit (at arrow "p1") showing that it was filled with a**

### Nickel-Cadmium deposit

Because of the Director of THY's overhaul shop's earlier comments that the SR holes were not inspected because the P&W engine manual did not specifically reference the SR holes, the Board examined the manner in which the manual addressed the inspection of the holes in the disk. The P&W engine manual presents a figure of the 7<sup>th</sup> stage disk, that shows only 12 holes (rather than the 24 holes that actually exist) and refers to them as tierod holes; the figure does not show the 12 SR holes. However, the 24 holes on an actual disk are placed so close together that it is virtually impossible to inspect tierod holes without noticing the SR holes. Textual material in the manual does indicate that 0.003-inch damage can be left without blending. However, the manual also states that no damage can exist in or near any hole. As previously noted, the FAA is working with P&W to revise P&W's JT8D engine manual in response to the Board's Safety Recommendation A-95-72.

The Safety Board concludes that although the P&W engine manual could have presented this information in a way that would have made it clearer that the SR holes in the 7<sup>th</sup> stage disk had to be inspected and could not contain any damage, the lack of clarity was not a contributing factor in the failure of the disk because the manual did clearly state that no damage was permissible in or near any hole.

The Safety Board attempted to determine why a proper inspection was not performed on the 7<sup>th</sup> stage disk. In the report of its 1991 shop review of the THY repair facility, P&W indicated that because the engine manual was written in English, THY should prepare "process sheets" in Turkish that describe the specific process and repair procedures and actual shop equipment to be used, and that require signatures of appropriate shop personnel for each significant step of the procedure as that procedure is completed. P&W indicated such documentation was not then being used by the THY repair station, and following the 1995 engine failure, none has been located for the 1991 inspection/overhaul of the 7<sup>th</sup> stage disk. Further, the report of the 1991 P&W shop review also pointed out that the job card that purportedly routed the parts through the FMPI inspection did not specify the process or have a signoff line. Also, the review indicated that several parts had been tagged with green wires indicating that the parts had been subjected to an FPI when they could not have received such an inspection, as no residual fluorescent background material was present on the parts. From this evidence, the Board concludes that the THY repair station was not using detailed documentation to provide step-by-step guidance at the time of the 1991 overhaul and inspection of the 7<sup>th</sup> stage disk.

The fact that the disk in this accident had plating over pitting and numerous cracks suggests that it had not received a proper overhaul or proper inspection for some time. Given that there is no historical evidence that the 7<sup>th</sup> stage HPC disk of the JT8D has been prone to developing cracks and ruptures, it is likely that a low or even zero rate of detection of cracks in this disk would create an expectation that no cracks would be detected. This could lead to complacency in the inspection process. This potential for complacency in the FPI/FMPI process, coupled with the failure to detect the crack in this case, raises questions regarding the adequacy of training procedures for such inspections. The 1991 P&W shop audit noted that THY's FPI/FMPI inspectors were trained by one another, and recommended that THY develop a formal training program or send the inspectors to a nondestructive testing school to become qualified and that they be retested every 1 to 2 years to ensure that they maintained their practical knowledge and theory. Because no additional information about THY's FPI/FMPI training was available for that time period (1991 and prior), the Safety Board was unable to further investigate or analyze this issue. However, the adequacy of FPI/FMPI training procedures will be thoroughly investigated and addressed in the Safety Board's ongoing investigation of the Delta Air Lines MD-88 uncontained engine failure in Pensacola, Florida.[42](#)

Nonetheless, despite the possibility that there may have been deficiencies in THY's training for FPI/FMPI, detailed documentation that specified each individual step in the inspection and overhaul process and required signatures could have instilled in THY personnel a greater sense of accountability and increased the likelihood that each step would be accomplished. Further, if the disk was inspected only on one side, or if it was not inspected at all, it is likely that detailed documentation that was required to be signed would have increased the likelihood that these failures would not have occurred. The Safety Board concludes that use of such detailed documentation would have increased the likelihood that the disk would have received a proper inspection and that the crack would have been detected, thus, the absence of such detailed documentation contributed to the accident.

Although detailed documentation would have increased the likelihood of the performance of a proper inspection, the Board is concerned that because of the dependency on human performance, a visual inspection, even enhanced (such as an MPI, FMPI, or FPI), may be an inappropriate inspection procedure when there is a low probability (expectation) of detecting a crack. The Board is examining this issue in its ongoing investigation of other uncontained engine failures and will address this issue further in its reports on those investigations.



## 2.4 Adequacy of FAA Recordkeeping Requirements.

The Safety Board's review of applicable regulations addressing the type and detail of records that are required to be retained by all repair stations indicates that FAA guidance in this area is insufficient and vague. Regulations governing maintenance practices in general (FAR 43.3) require that maintenance record entries contain only "a description (or reference to data acceptable to the [FAA] Administrator) of work performed." Regulations governing repair stations (FAR 145.61) require that repair stations keep "adequate records of all work [that they do]" but do not define what constitutes "adequate records." Regulations governing air carrier maintenance programs (FAR 121.380) require carriers to keep certain "records" (including records of the last complete overhaul of each airframe, engine, propeller, rotor, and appliance until the work is superseded by work of equivalent scope and detail) but do not define what sort of information, and what degree of detail, those "records" should contain. FAA Order 8130.2C, paragraph 220, indicates that "necessary maintenance documentation" must accompany an imported product before it can be returned to service, but there is no definition or clarification in paragraph 220 of what is considered "necessary maintenance documentation." Although it is possible that this is intended to refer to the maintenance records required to be kept by an owner or operator, as specified in FAR 91.417, [43](#) paragraph 219, "Identification and Marking," no such intention is explicitly stated in paragraph 220. In any event, because the records specified in FAR 91.417 are general maintenance records containing only very basic information, they are an insufficient basis on which to conclude that an item is airworthy, even assuming that is what is meant by "necessary maintenance documentation."

Although THY was alerted by P&W in 1991 that the lack of "process sheets" in the Turkish language represented a deficiency in its operation, it was not until June 1995 that such documentation (referred to as "traveler forms" by the Director of the THY overhaul shop) was used by the repair station. Further, although the documentation that the THY repair station began to use in June 1995 represents a significant improvement, those forms do not contain the level of detail contained in similar documentation used by some U.S. repair facilities. For example, the new THY "traveler forms" are generic to any disk and are not specific to any engine; that is, there is no form specific to the 7<sup>th</sup> stage HPC disk of a JT8D engine. Further, there is no reference on the form to specific sections of the engine maintenance manuals (or more detailed job instruction cards) that describe detailed instructions or references needed to complete the task. This type of information would not only help to ensure a proper overhaul or prevent a missed inspection, but would also help to assure the proper application of the overhaul and inspection procedures.

Another advantage to detailed documentation is that, if retained, it provides a much better basis for verifying the serviceability (or airworthiness) of engines/components being returned to service. The Safety Board concludes that "process sheets" or similar documentation of sufficient detail to permit a complete determination of the work needed to be done and of the work that has been done is necessary for a comprehensive maintenance program to ensure the continued airworthiness of aircraft, engines, and components. Such a system of documentation could be described in an advisory circular that sets forth one acceptable method for complying with the maintenance recordkeeping requirements. Therefore, the Safety Board believes that the FAA should revise the applicable regulations and provide specific guidance on the documentation to be used and kept during inspections and overhauls, including "process sheets" or similar detailed documentation for all certificated repair stations.

Although foreign repair stations are not subject to the same recordkeeping requirements as domestic repair stations, the Safety Board recognizes that most repair stations will voluntarily keep adequate records of work done and believes that the records available in this case met the minimum standards in existence at this time and were adequate for the consultant to conclude that the recordkeeping system was valid. Moreover, the Safety Board recognizes that even if THY had been subject to the same recordkeeping requirements as domestic repair stations, it still would not have been required to keep records of the 1991 disk overhauls because the engine was installed on a non-U.S. (Turkish) registered aircraft. Nonetheless, the Safety Board concludes that foreign repair stations should be subject to at least the same recordkeeping requirements as domestic repair stations and believes that the FAA should revise 14 CFR Part 145 to require Subpart C foreign repair stations to adhere to the same recordkeeping requirements of 14 CFR Part 145.61.

## 2.5 Maintenance Release and "Serviceable" Tags for Aircraft Components

Although the tag on engine SN 666966 described only that the engine had been preserved for up to 90 days, and FAA regulations state that the signature on a maintenance record entry constitutes approval for return to service only for the work performed, the technical control director of THY's repair station engine shop indicated that THY intended that the tag act as a full statement of serviceability and release for return to service based on a complete records review, rather than just the last maintenance action.

The Safety Board is aware that "serviceable" tags are routinely used by industry, vary considerably in format, and are sometimes relied upon as assurance of overall airworthiness. However, there appears to be no clear regulatory basis for such an assurance. The Safety Board concludes that the industry practice of using serviceable tags without a clear understanding of their purpose can result in the misinterpretation of the intent of these tags. The Safety Board believes that the FAA should require that "serviceable tags" be used to return engines and other component parts to service, that they be in a prescribed format (perhaps in the format of FAA Form 8130-3) and that when there is a change of ownership, and certainly upon importation, the approval for return to service attest to the overall airworthiness of the part. The tag should reflect that a complete and thorough review of records, including "process sheets" of the last overhaul, has taken place. In the absence of such records, an overhaul of the part should be required when there is a change in ownership.

## 2.6 THY's Authority to Overhaul JT8D Engines

The Safety Board received conflicting interpretations of THY's authority to overhaul JT8D engines. (Clearly, the engine involved in this accident was not overhauled under U.S. authority, but under Turkish authority.) In a memorandum dated November 16, 1995, responding to a Safety Board inquiry, the Director of the FAA's Flight Standards Service (AFS-1) stated that THY did not have JT8D engine overhaul authority from 1986-1994. However, THY maintains that its Air Agency Certificates and associated Repair Station Operations Specifications authorized THY to overhaul JT8D and other engines during those years.

In the Safety Board's view, the FAA 1986 Repair Station Operations Specifications can reasonably be read to indicate that THY's Limited Class 3 powerplant rating (authorizing all levels of maintenance, including overhaul) permitted overhaul of certain engines, including the JT8D, and that only line maintenance was authorized for Class 3 engines that were not listed on the operations specifications.

Because of the Safety Board's difficulty in understanding the FAA's contrary interpretation of this authorization, the Safety Board requested, in a letter to the FAA dated May 23, 1996, a clarification of the FAA's position on this issue. In a meeting with Safety Board staff on July 10, 1996, the FAA reiterated its position that THY did not have authority to overhaul JT8D engines for U.S.-certificated operations from 1986-1994. The FAA cited a phone call from THY in 1994 that requested expansion of the operations specifications to include engine overhauls. The Board remains convinced that the language of THY's operations specifications does not readily comport with the FAA's position, and the Safety Board is concerned that confusion about the extent of the authority of other repair stations may exist. Thus, the Safety Board believes that the FAA should review the Air Agency Certificates and Repair Station Operations Specifications of all repair stations and ensure that language in the operations specifications clearly indicates the extent of the repair stations' authority.

## 2.7 Emergency Lighting and Public Address System

When the airplane quickly filled with smoke after the engine failure, the pilots were able to complete only the first three items on the evacuation checklist before they exited the airplane. Further attempts by the pilots to complete the checklist could have exposed them to unnecessary risk. Because the fourth item on the checklist was not completed—moving the emergency light switch to the "ON" position—emergency lights in the cabin were not illuminated during a portion of the evacuation. Fortunately, in this accident, the lack of emergency lights in the cabin did not preclude a successful evacuation.

Several factors affected the timely and successful evacuation. Perhaps the most important was the ratio of exits to occupants. Six of the seven emergency exits were opened quickly (two floor-level exits at the front of the cabin and four overwing exits) and used by all 57 passengers. Additionally, the airplane had about half of its full complement of passengers, and except for the aft flight attendant, no occupants were injured or incapacitated, which would have slowed the evacuation. Finally, the cabin interior remained intact and no debris hampered access to the exits.

The pilot's first attempt to order an evacuation was not successful because electrical power to the PA system was lost when the engines were shut down. After the captain selected emergency electrical power (which caused the emergency lights to turn off), power was restored to the PA system and the captain successfully communicated the evacuation order. Although the delay in communicating the evacuation order did not adversely affect the evacuation, this accident again highlights the need for an independent power source for PA systems in transport-category airplanes.

The Safety Board has issued three safety recommendations over the years advocating an independent power source for PA systems. The first recommendation (A-74-111) was issued following a 1974 Safety Board special study<sup>44</sup> that examined 10 U.S. carrier accidents in which emergency evacuations occurred. The Board concluded in that study that PA systems are often used to initiate emergency evacuations but that they are not always available when aircraft power is interrupted. From 1974 to 1982, the FAA informed the Safety Board on several occasions that the issue was being evaluated for consideration in rulemaking action. However, in a letter dated August 18, 1982, the FAA indicated that it had determined that the cost of compliance with such a rule would outweigh any identifiable safety benefits. In a letter dated February 14, 1983, the Safety Board classified Safety Recommendation A-74-111 "Closed—Unacceptable Action."

In 1979, the Safety Board issued Safety Recommendation A-79-64 as a result of its investigation of a DC-8 accident in Portland, Oregon.<sup>45</sup> The recommendation urged the FAA to expedite the release of an operations review program notice that contained the 1974 recommendation for an independent power source for the PA system. The FAA subsequently issued an NPRM that contained the recommendation for an independent power source. Shortly thereafter, as a result of its investigation of a DC-8 evacuation in Phoenix, Arizona, on December 29, 1980,<sup>46</sup> the Board issued Safety Recommendation A-81-130, urging the FAA to adopt promptly the rule proposed in the NPRM. The FAA, however, subsequently determined that the cost of the proposed rule would outweigh the safety benefits and withdrew the NPRM. Safety Recommendation A-81-130 was therefore classified "Closed—Unacceptable Action."<sup>47</sup>

In May 1986, the FAA published an NPRM that would require an independent power source for PA systems in newly manufactured transport-category airplanes. In its comments on that rulemaking activity, the Safety Board supported the intent of the proposed rule but noted that the rule should also provide for the retrofit of all airplanes currently in service. On October 27, 1989, the FAA amended 14 CFR Part 121.318(g) to require that transport-category airplanes manufactured on or after November 27, 1990, be equipped with an independent power source for the PA system. The FAA did not include a provision for the retrofit of airplanes currently in service, as requested by the Safety Board.

Following the accident, the Douglas Aircraft Company modified the evacuation checklist by placing the activation of the emergency light switch at the beginning of the checklist. However, the Board is concerned that given the importance of the first three items on the checklist, placing the emergency light switch first may not be the safest course of action. Further, had the PA system had its own independent source of power as the Board has asked for in the past, then the pilots would not have had to select emergency power, and the emergency lights would have remained lighted during the evacuation of the airplane.

Communication is vital to a successful evacuation of any transport-category airplane, regardless of the date of manufacture. This accident again highlights the need for pilots to be able to communicate with passengers via the PA system without first turning off power to emergency lights. The Safety Board therefore believes that the FAA should require that all transport-category aircraft manufactured before November 27, 1990, be retrofitted with a PA system capable of operating on an independent power source.

## 2.8 ValuJet's Flight Attendant Training Program

The investigation of this accident disclosed deficiencies in ValuJet's flight attendant training program, including emergency drills training, and the FAA's inadequate oversight of this program. Although these deficiencies did not affect occupant survivability in this accident, they could adversely affect the outcome of future emergency situations.

ValuJet's flight attendant training program had been approved and the flight attendant manual had been accepted by the FAA principal operations inspector (POI) for ValuJet in September 1993. However, contrary to the requirements of 14 CFR Part 121, which require, in part, that crewmembers operate each type of emergency exit in its normal and emergency modes, ValuJet's flight attendant training syllabus did not include hands-on operation of a tailcone release handle.

The Safety Board has previously addressed this specific issue. Following the ground collision of a DC-9 and a B-727, and the subsequent fire on the DC-9 at Romulus, Michigan, on December 3, 1990,[48](#) a flight attendant and a passenger, both of whom died of smoke inhalation, were found inside the DC-9 tailcone. As a result of its investigation of that accident, the Safety Board issued Safety Recommendation A-91-6, which asked the FAA to immediately require operators of DC-9/MD-80 series airplanes to include in their flightcrew and flight attendant training programs hands-on training on the operation of the tailcone release handle in DC-9/MD-80 airplanes using actual airplanes or FAA-approved simulators.

In response to this recommendation, the FAA issued Air Carrier Operations Bulletin (ACOB) 8-76-6, "Guidelines for Crewmember Training on Aircraft Tailcones and Approval of Tailcone Training Devices," on July 13, 1992. The ACOB allowed air carriers to train their DC-9/MD-80 crewmembers by having an instructor or a trainee operate the tailcone release handle while other trainees observed. On January 6, 1993, the Safety Board classified Safety Recommendation A-91-6 "Closed—Unacceptable Action" because the Safety Board continued to believe that it was necessary for flightcrews and flight attendants to receive hands-on experience with every exit that they may be required to operate during an emergency evacuation.

Following this accident, the FAA, on January 26, 1996, issued Flight Standards Handbook Bulletin No. 96-02, "Guidelines for Crewmember Training on Aircraft Tailcones and Approval of Tailcone Training Devices." This bulletin sets forth acceptable means of approving tailcone training devices and ensures that trainees operate the mechanisms needed to ready the equipment for emergency evacuation, i.e., "each trainee must actually operate the appropriate mechanism to ensure evacuation through the tailcone exit."

As a result of the Safety Board's accident investigation, ValuJet purchased a tailcone training device to ensure that flight attendants receive the required training. As of August 31, 1995, all active ValuJet flight attendants had completed the Tailcone Mock-up Drill exercise.

The Safety Board is concerned, however, that the deficiencies in the flight attendant training program and the flight attendant manual raise serious questions about the adequacy of the FAA's review of the program and the manual before approval and acceptance by the FAA in September 1993. Although the deficiencies noted in this accident were subsequently addressed by the air carrier, the Safety Board believes that the FAA should emphasize to its POIs the importance of thoroughly reviewing flight attendant training programs before approving them and manuals before accepting them.

The investigation revealed that all four overwing exits were opened by passengers before the aircraft came to a complete stop. This is contrary to the ValuJet flight attendant training manual, which states that an evacuation should not be initiated until the aircraft has come to a complete stop. However, there is no indication that the flight attendants would have been able to prevent the passengers from opening the exit. Although the Safety Board concludes that there were no negative consequences in this case, the Safety Board is concerned that such premature actions may adversely affect safety and will continue to monitor this issue.

## 2.9 In-Lap Children over 2 Years Old

The investigation determined that one child more than 24 months old was listed as a lap child, despite Federal regulations that require all passengers more than 24 months old to be restrained during takeoffs and landings. The Safety Board has long been concerned about the inadequacy and enforcement of this regulation and, in the last several years, has identified at least six accidents and one enforcement action in which children more than 2 years old were unrestrained because they were held in someone's lap. The ages of these children ranged from 26 months to 5 years old.

During the Safety Board's public hearing following the 1989 DC-10 accident in Sioux City, Iowa, the Safety Board questioned the Air Transport Association (ATA) about the methods used by air carriers to ensure that all occupants are properly restrained. The ATA representative stated that it was "an uncertain art" and that because airlines were a "service industry," airline representatives would only question a passenger "if they felt that the causal observer could determine that the child was much larger and probably over two." According to FAA testimony at that public hearing, enforcement of this regulation depends on an FAA inspector observing that the child is more than 2 years old. One inspector discovered a child who was 5 years old being held on a lap; the inspector initiated enforcement actions.[49](#) The available evidence suggests that the FAA may only be enforcing this regulation when an egregious violation occurs.

The Safety Board continues to strongly believe that restraints should be available for all occupants, regardless of age. However, although the Safety Board does not agree with the existing regulation, until such time as restraints are required for all occupants, the Safety Board believes that the FAA needs to provide guidance on how to implement its requirement that occupants who are older than 2 years of age be restrained during takeoffs and landings.

## 2.10 Notification of Flightcrew of Cabin Fire

Although the right engine fire warning light illuminated, pilots received information that they had an engine fire from other pilots, and air traffic control personnel asked if emergency equipment was needed, the most timely and unambiguous information that there was a fire inside the airplane was provided by the flight attendants. The flight attendants, however, did not follow ValuJet's procedure that required the use of the interphone six-chime emergency signal to inform the cockpit of the fire. Because of the need for a flight attendant to retrieve a cockpit key from its storage area in the galley before being able to unlock the cockpit door, use of the six-chime signal would probably have been the faster way to notify the cockpit about the fire. However, the Safety Board has some concerns regarding the use of the interphone as the sole means of notifying the cockpit of an onboard fire. In an emergency situation, the cockpit crew may be too busy with other emergency tasks to immediately answer the interphone. In fact, the Safety Board has investigated accidents in which the flight attendant's interphone calls were not answered.[50](#) In this particular instance, however, it was fortunate that one of the flight attendants had her own cockpit key and thus was able to quickly notify the flightcrew about the fire.

The Safety Board is concerned that having only one cockpit key available and stored in the galley may not allow a key to be readily accessible to all flight attendants in an emergency. Also, relying solely on the six-chime emergency signal to be answered by the flightcrew in the cockpit when they may be preoccupied with other emergency procedures and tasks could result in the flightcrew not becoming aware as soon as possible that a fire exists in the cabin. The Safety Board concludes that all flight attendants should be able to quickly access the cockpit when appropriate.[51](#) Therefore, the Safety Board believes that the FAA should require that each flight attendant have a cockpit key in his/her possession at all times while on duty.



## 2.11 Fire Retardant Cabin Furnishings

The aircraft involved in this accident did not meet current regulations regarding flammability standards for materials used in the interiors of transport-category airplane cabins nor was it required to do so.

The Safety Board has long been concerned with the FAA's interpretation that new standard fire retardant cabin furnishing materials should be only required in the case of a "general retrofit." Airplane owners and operators are allowed to continue to perform piece-meal replacement of cabin furnishings using existing stocks of fire retardant parts that do not meet the 1985 standards. As the regulation is currently worded, an airplane in service for 20 or more years might never be subject to a "general retrofit."

During the Safety Board's investigation of the 1991 runway collision of a B-737 and a Metroliner at the Los Angeles International Airport,[52](#) it was documented that the B-737, which was manufactured before the effective date of the FAA 1985 standards, was not required to be, nor was it, equipped with upgraded fire retardant cabin furnishings. Of the 22 killed on board the B-737, 20 succumbed as a result of the inhalation of toxic smoke that was generated by the burning cabin furnishings.

The Safety Board subsequently issued Safety Recommendation A-91-116, which asked the FAA to "Prohibit the use, after a specified date, of cabin materials in all transport-category airplanes that do not comply with the improved fire safety standards contained in 14 CFR 25.853." On March 2, 1992, the FAA responded that it had evaluated this safety issue and had determined that in the case of the Los Angeles accident, it was unlikely that improved materials would have resulted in improved survivability. The FAA letter further indicated that it was not economically feasible to implement such a requirement. No further action was taken by the FAA, and the Safety Board ultimately classified the recommendation "Closed—Unacceptable Action" on September 19, 1994.

On January 6, 1993, the Government Accounting Office (GAO) submitted to the Congress a report on the status of how the airlines were progressing with installing more fire-resistant cabin materials in in-service airplanes.[53](#) The GAO report, stated the following, in part:

In establishing the stricter flammability standards, FAA anticipated that almost 85 percent of the fleet would comply by 2000 and indicated that it would consider proposing a mandatory retrofit requirement if all airlines did not meet the standards as anticipated. At the beginning of 1992, about 11 percent of the over 4,200 aircraft in the fleet complied with the standards. Although the number of newly manufactured aircraft meeting the standards will increase each year, no airline has replaced or plans to completely replace the interior components of aircraft that were in-service on August 19, 1990 (in service aircraft). As a result, 45 percent of the aircraft fleet is expected to be operating with cabin interiors not meeting the latest flammability standards by the end of the decade. In fact, under the current practice of replacing aircraft, the entire fleet is not expected to comply with the stricter flammability standards until 2018.

The total cost to the airlines to modify aircraft not meeting the standards would be several billion dollars and average over \$1 million per aircraft. Although costs can be reliably estimated, more uncertainty exists in reliably estimating the potential lives saved and their value because airline accidents occur infrequently and unpredictably, and no consensus exists on the value of a human life. FAA estimated that 9 to 16 lives could be saved each year if all aircraft met the stricter flammability standards. If the Department of Transportation's (DOT) current value of \$1.5 million for a human life were used to extrapolate a value for the potential fatalities avoided, then up to \$110 million could potentially be saved by modifying aircraft to meet the standards. However, one or two significant accidents could result in the loss of hundreds of lives and, depending on how high a value was used for a human life, the potential savings could be much higher.

Almost all aircraft that currently do not meet the flammability standards will undergo some type of routine heavy maintenance inspection by the end of the decade, providing airlines the opportunity to modify cabin interiors. However, airlines infrequently replace entire cabin interiors. Although a portion of the interior components is removed during a heavy maintenance inspection, airline officials told GAO that the components not meeting the standards are usually refurbished and reinstalled, rather than replaced with components that meet the standards. Industry practice is to replace a worn-out component with one that meets the standards if it is necessary to purchase a new component. However, this piecemeal replacement of individual



components will likely not significantly reduce the hazards posed by a post-crash fire.

As a result of its report, the GAO recommended that the Secretary of Transportation direct the FAA Administrator to reassess whether to issue a regulatory requirement mandating a specific date for all aircraft in the fleet to comply with the latest flammability standards for cabin interiors. Such a reassessment should compare the cost-effectiveness of retrofitting aircraft to meet the standards with other actions that could improve the overall safety of the U.S. aircraft fleet.

In response to this recommendation, the FAA reassessed its earlier cost-benefit analysis and again concluded that mandatory retrofit of improved cabin materials would not be cost beneficial, and thus, mandatory retrofit was not warranted.

The Safety Board concludes that the ValuJet accident in Atlanta again illustrates the merit of the Board's 1991 recommendation. This accident demonstrates the importance of the current standards and the need for existing aircraft to be brought up to these standards as quickly as possible. Consequently, the Safety Board believes that the FAA should prohibit the use during any type of replacement, after 1997, of cabin materials in all transport-category airplanes that do not comply with the current fire safety standards contained in 14 CFR 25.853. Furthermore, the FAA should amend 14 CFR Part 121 to prohibit, upon a transfer of the aircraft from one certificate holder to another, or by January 1, 2001, whichever occurs first, the operation of airplanes with cabin materials that do not meet the requirements of 14 CFR Part 25.853.

## 2.12 ValuJet Flight Attendant Uniforms

The FAA provides guidance to airline passengers in a brochure titled, "Fly Smart" (U.S. Department of Transportation, Federal Aviation Administration, ASP-200, 94/002). This brochure, among other things, addresses appropriate attire for passengers when flying. The brochure instructs travelers to wear "sensible" clothing, such as clothes made of natural fabrics, and recommends long sleeves and trousers that fully cover arms and legs.

The aft flight attendant who received the most serious injuries was wearing shorts and a short-sleeved shirt. Had she been wearing attire similar to that recommended in "Fly Smart," she may not have been burned. Therefore, the Safety Board believes that the FAA should issue an operations bulletin recommending that POIs advise their air carriers to disseminate FAA safety guidance on airline passenger attire to their flight attendants.

## 2.13 Quality of CVR Recording

The recording of the CVR installed on the accident airplane was considered to be a recording of only fair quality, in that many words were unintelligible, primarily because of the ambient noise in the cockpit. Although the quality of recording did not affect the determination of the causal factors in this accident, the Safety Board is concerned that the investigation of future accidents involving airplanes with similarly equipped CVRs could be impeded by unintelligible dialogue on the recording. The Safety Board has long been concerned about the quality of CVR recordings, as reflected in the following safety recommendation, which the Board issued to the FAA in June 1987:

Amend 14 CFR Parts 23 and 25 to require that all newly manufactured aircraft and new cockpit voice recorder installations be designed such that an uninterrupted recording from the boom or mask microphones and headphones for each flight crewmember's position and from an area microphone can be made on dedicated channels of the CVR. On those aircraft requiring only two flight crewmembers, the unused channel should record the passenger address audio signal when available. A sidetone shall be produced only when the transmitter or interphone is selected, and, in addition, all audio signals received by hand-held microphones shall be recorded on the respective crewmember's channel when keyed to the "ON" position. (A-87-88)[54](#)

In support of that recommendation, the Safety Board noted in its letter to the FAA that the Board had found the performance of CVR installations in which the audio signal from the boom microphone of each flight crewmember is continuously recorded on a dedicated channel, often referred to as a "hot mic," to be far superior to the standard cockpit area microphone (CAM), which is typically mounted on the cockpit overhead panel and picks up ambient noise. A CAM was installed on the ValuJet accident airplane. The Safety Board reached that conclusion after the investigation of several accidents/incidents involving both U.S.-registered and foreign-registered airplanes equipped with CVR "hot mics."[55](#) The Safety Board stated in its letter to the FAA that, in fact, the "hot mic" has proven to be a most significant technological improvement in CVRs and that the level of improvement far surpasses any technological improvement that could be achieved by state-of-the-art recording or signal processing equipment.

In contrast, the Safety Board noted that the quality of the audio signal recorded by the standard CAM can generally be described as fair, which requires considerable time and effort to produce a transcript, and which frequently can result in unintelligible dialogue.

Recent Safety Board accident investigations have continued to highlight the improved quality in recordings from CVR "hot mics."[56](#) These improvements have long been recognized by other aviation authorities. The Civil Aviation Authority of the United Kingdom has required CVR "hot mics" since 1974 on all aircraft registered in the United Kingdom. The adoption of CVR "hot mic" standards (not requirements) by the ICAO and EUROCAE was prompted, in part, by the United Kingdom's many years of experience in analyzing CVR "hot mic" recordings.

The Board's investigation of the ValuJet accident in Atlanta again raises concerns about the adequacy of CVRs equipped with the standard CAM. Given the numerous benefits of CVR "hot mics" and the slight cost of these installations, the Safety Board believes that the FAA should require all airplanes currently required to be installed with a CVR to be retrofitted within 2 years with a CVR "hot mic."

### **3. Conclusions**

### 3.1 Findings

1. The flightcrew met the certification, training, and rest requirements of the applicable Federal regulations before the accident, and the flight attendants had completed ValuJet's FAA-approved flight attendant training program in existence at the time of the accident.
2. The airplane was certificated and operated in accordance with applicable Federal regulations.
3. An uncontained failure of the right engine occurred at low airplane and high engine rotational speed, during the initiation of the takeoff roll. As a result of the uncontained failure, engine fragments penetrated the airplane's cabin, severing the right engine main fuel line and causing the release of pressurized fuel inside the cabin. Sparks that most likely were generated by steel engine fragments contacting steel galley components ignited a fire that quickly spread through the airplane's cabin.
4. The uncontained failure was caused by a fatigue crack in stress redistribution hole "1" in the 7<sup>th</sup> stage high compressor disk of engine SN 666966. The fatigue crack length was consistent with a critical crack length expected to produce separation of the disk under normal operating conditions.
5. Based on an analysis of fatigue striation measurements, a detectable crack existed in SR hole "1" in the 7<sup>th</sup> stage high compressor disk of engine SN 666966 when the disk was overhauled by the THY repair station in 1991.
6. The 7<sup>th</sup> stage high compressor disk of engine SN 666966 did not receive a proper inspection in when the disk was overhauled at the THY repair station in 1991.
7. Had the THY repair station accomplished a proper inspection of the 7<sup>th</sup> stage high compressor disk of engine SN 666966, the crack would probably have been detected, the part rejected, and consequently, the accident might have been avoided.
8. The THY repair station was not using "process sheets" at the time of the 1991 overhaul and inspection of the 7<sup>th</sup> stage high compressor disk of engine SN 666966, the use of such documents would have increased the likelihood that the disk would have received a proper inspection and that the crack would have been detected.
9. Although the P&W JT8D engine manual could have presented more precise information in terms of overhaul procedures and instructions, this lack of clarity did not contribute to the failure of the disk.
10. FAA guidance on what degree of detail is required in maintenance records is insufficient and vague.
11. "Process sheets" or similar documentation of sufficient detail to permit a complete determination of the work needed to be done and of the work that has been done is necessary for a comprehensive maintenance program to ensure the continued airworthiness of aircraft, engines, and components.
12. Foreign repair stations are not, but should be, subject to the same FAA recordkeeping requirements as domestic repair stations.
13. The industry practice of using serviceable tags without a clear understanding of their purpose can result in the misinterpretation of the intent of these tags.
14. Although there were conflicting interpretations of THY's authority to overhaul JT8D engines by the FAA and THY, the Repair Station Operations Specifications in question can reasonably be read to indicate that THY did have authority under Part 145 to overhaul JT8D engines at the time engine SN 666966 was overhauled in 1991.
15. The fourth item on the evacuation checklist was not completed by the flightcrew because of

smoke accumulation in the cockpit; as a result, emergency lights were not available during a portion of the evacuation. Fortunately, the lack of emergency lights did not preclude a successful evacuation.

16. Although the pilot's delay in communicating the evacuation order because of an electrical power loss did not adversely affect the evacuation, the accident again highlights the need for an independent power source for public address systems in transport-category airplanes.

17. Although deficiencies in ValuJet's flight attendant training program, including emergency drills training, and the FAA's inadequate oversight of this program did not affect occupant survivability in this accident, they could have.

18. Although Federal regulations require that all passengers more than 24 months old be restrained during takeoff and landing, this accident again demonstrates that this regulation is not always enforced, as one child who was more than 24 months old was listed as a lap child and was seen being held in an adult passenger's lap.

19. Because one of the flight attendants had her own key for the cockpit, she was able to quickly notify the flightcrew about the fire. ValuJet procedures in effect at the time did not provide for prompt flight attendant access to the cockpit.

20. The aircraft involved in this accident did not meet current regulatory requirements regarding flammability standards for materials used in the interiors of transport-category airplane cabins nor was it required to do so. However, this accident demonstrates the importance of the current standards and the need for existing aircraft to be brought up to these standards as quickly as possible.

## 3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the failure of Turk Hava Yollari maintenance and inspection personnel to perform a proper inspection of a 7<sup>th</sup> stage high compressor disk, thus allowing the detectable crack to grow to a length at which the disk ruptured, under normal operating conditions, propelling engine fragments into the fuselage; the fragments severed the right engine main fuel line, which resulted in a fire that rapidly engulfed the cabin area. The lack of an adequate recordkeeping system and the failure to use "process sheets" to document the step-by-step overhaul/inspection procedures contributed to the failure to detect the crack and, thus, to the accident.

## 4. Recommendations

As a result of this accident investigation, the National Transportation Safety Board recommends that the Federal Aviation Administration:

Review the Air Agency Certificates and Repair Station Operations Specifications of all repair stations and ensure that the language used in the operations specifications clearly indicates the extent of the repair stations' authority. (Class II, Priority Action)(A-96-78)

Revise 14 CFR Part 145 to require Subpart C foreign repair stations to adhere to the same recordkeeping requirements as domestic repair stations. (Class II, Priority Action)(A-96-79)

Revise the applicable regulations and provide specific guidance on the documentation to be used and kept during inspections and overhauls, including "process sheets" or similar detailed documentation for all certificated repair stations. (Class II, Priority Action)(A-96-80)

Require that "serviceable tags" be used to return engines and other components to service, that they be in a prescribed format (perhaps in the format of FAA Form 8130-3), and that when there is a change of ownership, and certainly upon importation, the approval for return to service attest to the overall airworthiness of the part and the tag reflect that a complete and thorough review of records, including "process sheets" of the last overhaul, has taken place. In the absence of such records, require an overhaul of the part when there is a change in ownership. (Class II, Priority Action)(A-96-81)

Require that all transport-category aircraft manufactured before November 27, 1990, be retrofitted with a public address system capable of operating on an independent power source. (Class II, Priority Action)(A-96-82)

Emphasize to principal operations inspectors the importance of thoroughly reviewing flight attendant training programs before approving them and flight attendant manuals before accepting them. (Class II, Priority Action)(A-96-83)

Provide guidance on how to implement the requirement that occupants who are more than 24 months old are restrained during takeoffs, landings, and during turbulence. (Class II, Priority Action)(A-96-84)

Require that each flight attendant have a cockpit key in his/her possession at all times while on duty. (Class II, Priority Action)(A-96-85)

Prohibit the use during any type of replacement, after 1997, of cabin materials in all transport-category airplanes that do not comply with the current fire safety standards contained in 14 CFR 25.853. (Class II, Priority Action)(A-96-86)

Amend 14 CFR Part 121 to prohibit, upon a transfer of the aircraft from one certificate holder to another, or by January 1, 2001, whichever occurs first, the operation of airplanes with cabin materials that do not meet the requirements of 14 CFR Part 25.853. (Class II, Priority Action)(A-96-87)

Issue an operations bulletin recommending that principal operations inspectors advise their air carriers to disseminate Federal Aviation Administration safety guidance on airline passenger attire to their flight attendants. (Class II, Priority Action)(A-96-88)

Require all aircraft currently required to be installed with a cockpit voice recorder (CVR) to be retrofitted within 2 years with a CVR installation designed such that an uninterrupted recording from the boom or mask microphones and headphones for each flight crewmember's position and from an area microphone can be made on dedicated channels of the CVR. A sidetone shall be produced only when the transmitter or interphone is selected, and, in addition, all audio signals received by hand-held microphones shall be recorded on the respective crewmember's channel when keyed to the "ON" position. (Class II, Priority Action)(A-96-89)



BY THE NATIONAL TRANSPORTATION SAFETY BOARD

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**August 30, 1996**

## **5. Appendixes**

## **Appendix A - Investigation And Hearing**

## 1. Investigation

The National Transportation Safety Board was initially notified of this accident about 1915 on June 8, 1995, by the FAA. One investigator from the Safety Board's Southeast Field Office was immediately dispatched to the scene. A Washington-based team departed for the scene the following morning. The team consisted of investigative groups in the areas of Operations, Structures/Systems, Performance, Materials, Powerplants, Survival Factors, and Maintenance/Records.

Parties to the investigation were the FAA, ValuJet, the Douglas Aircraft Company, Pratt & Whitney, and the Association of Flight Attendants.

## 2. Hearing

No public hearing was held in connection with this accident investigation.

## **Appenix B-Cvr Transcript**

**National Transportation Safety Board Engineering & Computer Services Division Washington, D.C. 20594**

## **SPECIALIST'S FACTUAL REPORT OF INVESTIGATION**

Cockpit Voice Recorder

by Albert G. Reitan Transportation Safety Specialist

The reader of this report is cautioned that the transcription of a CVR tape is not a precise science but is the best product possible from an NTSB group investigative effort. The transcript, or parts thereof, if taken out of context, could be misleading. The attached CVR transcript should be viewed as an accident investigation tool to be used in conjunction with other evidence gathered during the investigation. Conclusions or interpretations should not be made using the transcript as the sole source of information.

ATL 95 MA 106

June 20, 1995

**A. ACCIDENT**

Location: Atlanta Hartsfield Airport - Atlanta, Georgia

Date: June 8, 1995

Time: 1908 Eastern Daylight Time (EDT)

Aircraft: DC-9-32, N908VJ

**B. GROUP**

Chairman: Albert G. Reitan  
Transportation Safety Specialist (CVR)  
National Transportation Safety Board

Member: Martin H. (Hop) Potter  
Aviation Safety Inspector  
Federal Aviation Administration

Member: Webster C. Heath  
Manager Tecchnical Liaison Industry Regulatory Affairs  
McDonnell Douglas

Member: Paul D. Weston  
Captain  
ValuJet

Member: Bruce A. Samborski  
Airworthiness Engineer  
United Technologies, Pratt & Whitney



**B. GROUP**

Chairman:	Albert G. Reitan Transportation Safety Specialist (CVR) National Transportation Safety Board
Member:	Martin H. (Hop) Potter Aviation Safety Inspector Federal Aviation Administration
Member:	Webster C. Heath Manager Tecchnical Liaison Industry Regulatory Affairs McDonnell Douglas
Member:	Paul D. Weston Captain ValuJet
Member:	Bruce A. Samborski Airworthiness Engineer United Technologies, Pratt & Whitney

## **C. Summary**

A Fairchild model A-100A cockpit voice recorder (CVR), s/n 53333, was brought to the audio laboratory of the National Transportation Safety Board on June 9, 1995. The Cockpit Voice Recorder committee convened on June 13, 1995. A transcript was prepared of the entire 31:16 minute recording. (attached)

## D. Details Of Investigation

The exterior of the CVR showed no evidence of structural damage. It was covered with a light coating of soot. The interior of the recorder and the tape sustained no apparent heat or impact damage.

The recording consisted of three channels of fair quality audio information. The area microphone channel contained a large amount of background noise so the pilot voices were read only with great difficulty. A second channel contained information from the pilots' audio panels and a third contained the interphone and public address information.

The recording started at 1838:03 EDT and continued uninterrupted except for a one second interval until 1908:20 EDT when electrical power was removed from the unit. When the recording started, the flight was at the gate preparing for departure. The recording continued as the crew prepared for departure and taxied to the departure runway. The recording ended when the aircraft stopped on the runway after experiencing an engine problem.

As part of the Safety Board's accident investigation process, the cockpit flightcrew was invited to review the CVR group's transcript and suggest corrections or additions. The captain and first officer reviewed the CVR recording and transcript on June 28, 1995, and suggested the following changes:

Page 15

1902:42 [25:37]  
CAM-1 flaps five, before takeoff check list.

Page 16

1902:56 [25:51]  
CAM-2 performance data and bugs?  
1903:51 [26:46]  
CAM-1 set and, \*\* ANU.  
1904:50 [27:45]  
CAM-1 five flaps, one thirty uh, climb to ten thousand feet, heading whatever they give us, \* nine five.  
1905:45 [28:40]  
CAM-1 hey Meg.

Page 17

1905:51 [28:46]  
CAM-1 \* the mark of a true professional if you can keep talking like that.

Page 18

1907:54 [30:49]  
CAM-? alright, here, they're spooled.

Albert G. Reitan

**Transportation Safety Specialist (CVR)**

Transcript of a Fairchild A-100A cockpit voice recorder (CVR), s/n 53333, installed on an Douglas DC-9-32, N908VJ, which was which sustained an engine failure during takeoff from Atlanta Hartsfield International Airport on June 8, 1995

## LEGEND

RDO	Radio transmission from accident aircraft
CAM	Cockpit area microphone voice or sound source
INT	Transmissions over aircraft interphone system
ATIS	Radio transmission from Atlanta Departure ATIS
GND	Transmission received from Atlanta <b>south</b> ground control
TWR	Transmission received from Atlanta tower
PA	Transmission made over aircraft public address system
CLR	Radio transmission from unidentified aircraft
TR-?	Radio transmission from unidentified aircraft
-1	Voice identified as Pilot-in-Command (PIC)
-2	Voice identified as Co-Pilot
-3	Voice identified as 1st female Flight Attendant
-4	Voice identified as 2nd female Flight Attendant
-5	Voice identified as female ground agent
-6	Voice identified as male ground agent
-?	Voice unidentified
*	Unintelligible word
@	Non pertinent word
#	Expletive
%	Break in continuity
( )	Questionable insertion
[ ]	Editorial insertion
....	Pause

Times are expressed in eastern daylight time (EDT). Times shown in brackets [ ] are computer reference times measured from the beginning of the recording.

TIME & SOURCE	CONTENT	TIME & SOURCE
START of RECORDING		
START of TRANSCRIPT		
1838:03	[00:58]	
CAM-6	gentlemen, any write ups?	
1838:04	[00:59]	
CAM-2	actually our uh, transponder, TCAS fail light stays on.	
1838:11	[01:06]	
CAM-6	fail light stays on?	
1838:12	[01:07]	
CAM-2	yeah, so we don't get any contacts or anything that it's working.	

1838:20 [01:15]  
CAM-6 Mar\* Mike, Mar\* Mike.  
1838:23 [01:18]  
CAM-2 captain, do you want to write it up \*?  
1838:25 [01:20]  
CAM-? \*\*,  
1838:27 [01:22]  
CAM-6 anything you want to write up?  
1838:27 [01:22]  
CAM-1 no.  
1838:29 [01:24]  
CAM-6 you wanna wait till you get back?  
1838:31 [01:26]  
CAM-1 yeah, we're running late.  
1838:35 [01:30]  
CAM-1 depends on how long we're going to take.  
1838:36 [01:31]  
CAM-6 we're gonna have to bring avionics guy out here and uh.  
1838:40 [01:35]  
CAM-? and uh,  
1838:46 [01:41]  
CAM-2 \*\*\*\* radar altimeter may have something to do with it.  
1838:50 [01:45]  
CAM-1 the altimeter, yeah.  
CAM-6 if you want it fixed, I'll call'em out here, you know, that's up to you.  
1838:57 [01:52]  
CAM-2 he he did not want to write it up.  
1838:58 [01:53]  
CAM-6 he didn't?  
1838:59 [01:54]  
CAM-2 no.  
1839:00 [01:55]  
CAM-6 he gonna write it back up on the way in.  
1839:02 [01:57]  
CAM-2 we will do that.

1839:03 [01:58]  
CAM-6 OK, alright, we just don't think \*\*\*\*\* pin it on us.  
1839:35 [02:30]  
CAM [sound of non pertinent flight attendant conversation in back-ground]

1839:35

ATIS

1842:38 [05:33]  
CAM-2 hi, how you doing?  
1842:40 [05:35]  
CAM-3 \*\*\*\*\* please gentlemen.  
1842:42 [05:37]  
CAM [several unintelligible flight attendant pilot comments]  
1843:13 [06:08]  
CAM-3 what time are we gonna get home now, eleven?  
1843:16 [06:11]  
CAM-2 let's see. we're supposed to get home at nine thirty five.  
that's taking off at five thirty five. \*\* four hours.  
1843:34 [06:29]  
CAM-3 two hours (late, we'll get in at \*\*\*\*\* eleven thirty \*\*\*\*\*).  
1843:41 [06:36]  
CAM-2 OK, is that it now?  
1843:42 [06:37]  
CAM-4 we're still waiting on catering.  
1843:44 [06:39]  
CAM-2 OK,  
1843:45 [06:40]  
CAM-? \*\* eighteen  
1843:46 [06:41]  
CAM-2 OK. \*\*\*\*\*

1843:48 [06:43]

CAM-2 yeah, thirty five.

1843:52 [06:47]

CAM-? [sound of laughter]

1844:00 [06:55]

CAM-1 ninety three, I'll tell you what, the temperature wasn't much different down there.

1844:03 [06:58]

CAM-2 oh yeah.

1844:56 [07:51]

CAM [bell sound similar seat belt chime]

1844:57 [07:52]

CAM-1 well.

1844:59 [07:54]

CAM-1 what did they finally decide? are we taking folks with us to several cities or just Miami?

1845:07 [08:02]

CAM-? I think it's Miami. \* \* \* \* \* thirty five \* \* thirty nine.

1845:19 [08:14]

CAM-1 have we called 'em a couple of times already?

1845:23 [08:18]

CAM-5 I haven't done anything.

1845:27 [08:22]

CAM-1 you talked to them at all about catering?

1845:28 [08:23]

CAM-2 no. that's the first I've heard.

1845:30 [08:25]

CAM-1 OK.

1845:31 [08:26]

PA-3 Good evening ladies and gentlemen. we would like to welcome you aboard ValuJet's flight five ninety seven now non-stop service to Miami. as you are getting comfortably seated, we do need to remind you that every bit of the carry-on luggage you brought on board, needs to either go underneath the seat in front of you or in one of the overhead compartments. If you need any assistance with your luggage, please let one of us know at this time. in addition federal regulations require all passengers seated in emergency exit rows fourteen, fifteen, and sixteen, to be responsible for these exits and for assisting others in the event of an emergency. if you are unable or do not wish to perform these emergency duties, please let Denise know at this time, she'll be happy to change you to another seat.

just a reminder, this is a non smoking flight. your compliance is required by federal aviation regulations. Thank you for your attention and welcome aboard.

1846:22

RDO-1

1846:29

CLR

1846:35

RDO-1

1846:40

CLR

1846:44

RDO-1

1846:50

CLR

1847:04

RDO-1

1847:07

CLR

1847:17 [10:12]

CAM-2 (one) thirty three.

1847:20 [10:15]

CAM-3 they get these from you? up there?

1847:22 [10:17]

CAM-? \*\*\* we checked \*\*\*\*\*.

1847:27 [10:22]

CAM-3 alright.

1847:33 [10:28]

CAM [several unintelligible comments between pilots and flight attendants]

1848:11 [11:06]

CAM-1 tell her we're about to \*\*\*\*\* you want to write it up \*\*\*\*\*.

1848:50 [11:45]

CAM-? count thirty three and twenty four right now. thirty three up



front twenty four in the back.

1849:08 [12:03]

PA-1 folks good evening and welcome aboard. I'm Greg Straessle your captain along with your co-captain Steve Rasin. Rachel, Magen, and Denise in the back to take good care of you. it's a one hour nineteen minute flight down to Miami, Florida. w'be taking out of here very shortly heading on down there scattered clouds, a little cooler in Miami than it is here, actually. it's ninety three degrees in Miami, ninety four here at about ten knots of wind down there. seat belt sign's on if you would please uh, observe that and fasten 'em up snugly. we'll be under way very, very shortly here uh, we apologize for the delay. it started a while back uh, with a little bit of a maintenance problem that was cured but just took a little longer than we wanted it to to progress and finally get fixed. so as I say we'll be under way shortly and get you there as soon as we can. thank you for joining us today.

1850:01 [12:56]

CAM [unintelligible conversation overridden by nearby jet engine noise]

1850:41 [13:36]

CAM-1 \*\*\*\*\* ninety nine?

1850:46 [13:41]

CAM [more unintelligible conversation]

1852:33 [15:28]

CAM-3 there's \*\*.

1852:53 [15:48]

CAM-5 hello.

1852:54 [15:49]

CAM-? hi, how ya doing?

1852:56 [15:51]

CAM-5 we got two hundred and ten pounds in the hold in the front. we got fifty bags in the rear, and ten bags in the front. going out southbound? take the power off and raise the stairs?

1853:13 [16:08]

CAM-2 yeah, you sure can.

1853:14 [16:09]

CAM-5 alright, and the stairs and hydraulics on?

1853:16 [16:11]

CAM-2 yep it's on.

1853:16 [16:11]

CAM-5 alright, thank you.

1854:12 [17:07]

CAM-? what are they \*\*.   
1854:13 [17:08]   
CAM-2 uuuh.   
1854:17 [17:12]   
CAM-? not them.   
1856:53 [19:48]   
CAM-5 catering guy. \*\* you ready?   
1856:55 [19:50]   
CAM-? we're ready.   
1856:58 [19:53]   
CAM-5 OK, see you later.   
1857:06 [20:01]   
CAM-5 what time are you guys goin' out?   
1857:08 [20:03]   
CAM-1 uuuuh, fifty five, what do you want?   
1857:10 [20:05]   
CAM-5 OK, that sounds good.   
1857:18 [20:13]   
CAM-1 soon as they close the cargo door.   
1857:26 [20:21]   
CAM-3 everybody's down.   
1857:31 [20:26]   
PA-3 flight attendants prepare for departure please, cross check.   
1857:57 [20:52]   
CAM [sound of two dings]   
1858:06 [21:01]   
CAM-? ninety four \*\*\*.   
1858:12 [21:07]   
CAM [sound of single ding]   
1858:15 [21:10]   
CAM-1 \*\*\*\*\* starting engines check list. OK.   
1858:41 [21:36]   
CAM-1 starting two, lets go below the line please.   
1858:43 [21:38]   
CAM-2 clearance to start?

1858:43	[21:38]
CAM-1	received.
1858:44	[21:39]
CAM-2	shoulder harness? on.
1858:45	[21:40]
CAM-1	comin' on.
1858:46	[21:41]
CAM-2	parking brakes?
1858:46	[21:41]
CAM-1	they're set.
1858:47	[21:42]
CAM-2	fuel quantity? twenty four one.
1858:48	[21:43]
CAM-1	I see it, rechecked. twenty four plus.
1858:51	[21:46]
CAM-2	pneumatic crossfeeds?
1858:52	[21:47]
CAM-1	are open.
1858:52	[21:47]
CAM-2	anti-collision lights?
1858:53	[21:48]
CAM-1	on.
1858:54	[21:49]
CAM-2	air conditioning supply switches?
1858:54	[21:49]
CAM-1	off.
1858:55	[21:50]
CAM-2	fuel boost pumps?
1858:56	[21:51]
CAM-1	on.
1858:56	[21:51]
CAM-2	ignition?
1858:58	[21:53]
CAM-1	comin' on right side, that **.
1859:08	[22:03]

CAM-1	oil,
1859:09	[22:04]
CAM-1	N2,
1859:12	[22:07]
CAM-1	N1,
1859:15	[22:10]
CAM	[sound of click]
1859:16	[22:11]
CAM-1	fuel.
1859:21	[22:16]
CAM	[sound similar to engine increasing in frequency]
1859:28	[22:23]
CAM-1	** cut out, slower start, acceleration **, on the line.
1859:40	[22:35]
CAM-1	oil,
1859:42	[22:37]
CAM-3	uh,
1859:51	[22:46]
CAM-1	fuel
1859:52	[22:47]
CAM	[sound similar to engine increasing in frequency]
1900:01	[22:56]
CAM	[sound of two dings]
1900:05	[23:00]
CAM-2	electrical panel?
1900:06	[23:01]
CAM-1	set.
1900:06	[23:01]
CAM-2	ignition?
1900:07	[23:02]
CAM-1	off.
1900:07	[23:02]
CAM-2	pitot static heat?
1900:08	[23:03]
CAM-1	on.

1900:08	[23:03]
CAM-2	ice protection?
1900:09	[23:04]
CAM-1	off.
1900:09	[23:04]
CAM-2	center tank pumps?
1900:10	[23:05]
CAM-1	on.
1900:10	[23:05]
CAM-2	flight attendant signal?
1900:11	[23:06]
CAM-1	given.
1900:12	[23:07]
CAM-2	air conditioning?
1900:12	[23:07]
CAM-1	auto.
1900:13	[23:08]
CAM-2	door lights?
1900:13	[23:08]
CAM-1	out.
1900:14	[23:09]
CAM-2	hydraulic pumps?
1900:15	[23:10]
CAM-1	set.
1900:19	[23:14]
CAM	[several unintelligible comments overridden by loud engine noise]
1901:03	[23:58]
CAM-2	clear on the right.
1901:30	[24:25]
PA-3	once again good evening ladies and gentlemen. we would like to welcome you aboard ValuJet's flight 597 now non-stop service to down to Miami. on the flight deck is captain Greg Straessle. he's assisted by first officer Steve Rasin. my name is Megan. working along with me this evening are Rachel and Denise. your flight attendants are one of the most important safety features of this aircraft. we do ask for your attention for just a few minutes as we go over some very important information with you. we do request that you please read the safety information card located in the seat pocket in front of you as we explain the safety features of

our DC-9-32 aircraft. at this time Denise and Rachel will demonstrate the easy operation of your seat belt. first insert the flat metal end into the buckle. to adjust pull on the loose strap. to release simply lift up on the buckle. seat belts should always be fastened when the seat belt sign is illuminated. on this particular aircraft there are three door exits, two at the front of the aircraft and the tail cone exit at the rear of the aircraft. all door exits are equipped with evacuation slides. in addition there are four window exits, two over each wing. all exits are clearly marked to assist you in locating them. there is also a lighting system in the floor which will illuminate in an emergency. red lights indicate you have reached or are near an exit. the cabin is pressurized for your comfort, however if oxygen is needed an oxygen panel will drop from a compartment above your seat. you would reach up and pull down on the mask until the tubing is fully extended. place the mask over your nose and mouth, secure it with the elastic band, and breath normally. the oxygen bag may not appear to inflate, however oxygen is flowing. for those of you traveling with small children please adjust your mask first and then assist your child. the passenger seat cushions on this aircraft can be used as flotation equipment. detailed instructions on its use are found on the back side of the safety instruction card. smoking is not permitted at any time on board our aircraft. federal law prohibits tampering with the smoke detectors that are in our aircraft lavatories. your compliance with crewmembers' instructions, all placards, lighted seat belt and no smoking signs is required. also please keep in mind that due to possible interference with our navigational systems the following electronic devices may not be used during takeoff and landing: portable compact disk players, portable computers, and cellular phones should now be in the off position and stowed. in preparation for our takeoff this evening please double check and make sure your seat belts are securely fastened around you. please bring your tray tables and seat backs to the their full upright and locked position, and all carry on luggage should be underneath the seat in front of you completely, or in one of the overhead bins. the captain has informed me that our flying time down to Miami will be one hour and nineteen minutes. we sincerely do appreciate your attention, and welcome aboard.

1902:25

RDO-2

1902:31

GND

1902:34

RDO-2

1902:42 [25:37]

CAM-1 flaps five \*\*\* check list.

1902:43 [25:38]

CAM-2 flaps five.

1902:56 [25:51]

CAM-2 data and bugs?  
 1902:57 [25:52]  
 CAM-1 alright I see \*\*\* do you agree?  
 1903:49 [26:44]  
 CAM-2 trim controls?  
 1903:51 [26:46]  
 CAM-1 set and,  
 1903:55 [26:50]  
 CAM [sound similar to stabilizer trim in motion]  
 1904:15 [27:10]  
 CAM-1 set and six.  
 1904:18 [27:13]  
 CAM [unintelligible conversation between pilot and flight attendant]  
 1904:45 [27:40]  
 CAM-1 looks like we're gonna get right outta here.  
 1904:50 [27:45]  
 CAM-1 five flaps, one thirty uh, ten thousand feet, heading whatever they give us, \* nine five.  
 1905:22 [28:17]  
 CAM [several unintelligible comments between pilots]  
 1905:45 [28:40]  
 CAM-2 hey Meg.  
 1905:50 [28:45]  
 CAM-3 what, yes sir.  
 1905:51 [28:46]  
 CAM-2 \* the mark of a true faithful if you can keep talking like that.

1906:02

TWR

1906:04

RDO-2

1906:09 [29:04]  
 PA-2 flight attendants take your seats for departure.  
 1906:21 [29:16]  
 CAM-2 anti-skid?  
 1906:22 [29:17]

CAM-1 yep.

1906:29 [29:24]

CAM-2 cockpit door? locked.

1906:30 [29:25]

CAM-2 ignition? on.

1906:30 [29:25]

CAM-2 APU? off.

1906:31 [29:26]

CAM-2 flight attendant signal? given.

1906:32 [29:27]

CAM-2 anti-skid? is armed.

1906:33 [29:28]

CAM-2 TCAS transponder? TA RA.

1906:34 [29:29]

CAM-2 pneumatic cross-feeds? closed.

1906:35 [29:30]

CAM-2 annunciator panel? checked.

1906:36 [29:31]

CAM-2 takeoff briefing? accomplished. before takeoff checklist complete.

1907:34

TWR

1907:39

RDO-2

1907:45 [30:40]

CAM [sound similar to increase in engine RPM]

1907:54 [30:49]

CAM-? \*here\*.

1907:58 [30:53]

CAM [one second interruption in CVR audio]

1907:58 [30:53]

CAM [repetitive thumping sounds lasting for three seconds]

1908:00

TR-?



1908:02

RDO-2

1908:06

TWR

1908:08 [31:03]

CAM-3 \*\*.

1908:08 [31:03]

CAM-1 OK.

1908:09 [31:04]

CAM-1 yes, roll the equipment.

1908:10

RDO-2

1908:10 [31:05]

CAM [sound of commotion from passenger cabin]

1908:15 [31:10]

PA-3 flight attendant, ladies and gentlemen, please wait until the plane comes, ladies.

1908:20 [31:15]

CAM [sound similar to engine decreasing in RPM]

1908:21 [31:16]

END of  
RECORDINGEND of  
TRANSCRIPT

## **Appendix C - Example of a "Process Sheet"**

## Master Routing List

p1,1,1,1,0p,7,1,2,b,nb,39,+,8,10,10,0000000000c,h,+,12,450,1,5378179

Initialized by:

Issued By:

Loc: c002

Date:

Manual Ref: 72-36-41

P/N: c002

Description: C-7 DISK

Qty.: 1

Customer:

Section: REAR COMPRESSOR GROUP(03)

Engine Model:

S/N:

s/n:

Repair Order: 0

Form: 723641

Revision: 16

Revision Date: 08/24/94

**Repairs Slected:**

## Repair Description:

01	-Surface Damage Blending
	-
02	-Ni-Cad Plate
	-
02A	-Sermetel Coating
	-
03	-Disk Bore Machining
	-
04	-Tierod Hole Machining
	-
06	-Corrosion Pitting
	-
06 AC	-Corrosion Inspection Prior To Mag/Zyglo.
	-
06 KK	-Corrosion Inspection After Mag/Zyglo.
	-
09	-Front Spacer Mating Surface Machining
	-
10	-Rear Spacer Mating Surface Machining
	-
11	-Front Snap Diamater Nickel Plate.
	-
12	-Rear Snap Diameter Nickel Plate.
	-
14	-Center Rail Face Galling Repair
	-
DS	-Deblade Disk
	-

**Routing Sequence:**

Oper.	10	20	30	35	37	40	50	53	55	75	77
Dept.	256	202	614	228	228	603	610	256	604	604	256
Oper.	80	90	100	110	120	130	145	147	150	155	157
Dept.	230	27	27	27	27	27	614	228	614	228	610
Oper.	158	160	180	200	210	220	230	240	250	0	0
Dept.	256	614	614	614	614	611	623	256	256		

**Routing Operations:**

Oper.#	Shop Code	Department	Remarks	Sign Mech
10	256	H/C CELL INSPECTIO	Initial Inspect (Inspect-01) Initial inspect and mark for routing required.	N/A
20	202	COMPRESSOR DISSY.	Remove Blades Deblade disk OK Bg: _____	
30	614	SUPPT. SHOP PLATING	Strip Ni-Cad (repair-02) Strip Ni-Cad per SPOP 25 I/A/W standard practices manual 70-44-01 pg 65 operation 1 thru 14. (Note: Mask nickel/plasma repaired areas per SPOP 36 prior to stripping Ni-Cad. Dip in Alkali Electro Cleaner to remove residue.	
35	228	COMPRESSOR MACH. SH	Initial Machine Front Snap Diameter (repair-11) Initial machine the front snap diameter to 16.296" - 16.315. Hold to minimum dimension. Actual dimension M: _____	
37	228	COMPRESSOR MACH. SH	Initial Machine Rear Snap Diameter (repair-12) Initial machine the rear snap diameter to 15.474" - 15.493". Hold to minimum dimension. Actual dimension M: _____	
40	603	SUPPT.SHOP CLEANIN	Strip Sermetel (repair-02) Strip Sermetel per SPOP 258.	
50	610	SUPPT.SHOP GRITBLA	Grit Blast Corrosion (repair-06) Blast disk to remove corrosion per SPOP 218. (Note: Do not blast tierod holes).	
53	256	H/C CELL INSPECTIO	Inspect Corrosion Damage (inspect-02) Inspect disk for corrosion damage.	N/A
55	604	SUPPT.SHOP NDT	Magnaflux Inspect Disk (repair-06) Magnetic partical inspect per SPOP 112, NDT coil 2500A, rod 3000A.	N/A
75	604	SUPPT. SHOP NDT	Inspect for Magnetization (repair-02) Inspect the disk for magnetization. If disk is magnetized follow the demagnetization procedure in the standard practice manual 70-44-01 pg 1. Recheck for magnetization and repeat procedure if nesessary until satisfactory results have been obtained. Actual magnetic field reading I:_____	N/A
77	256	H/C CELL INSPECTIO	Inspect Corrosion Damage (inspect-02)	N/A

			Inspect disk for corrosion damage.
80	230	COMPRESSOR REWORK	Blend Out Surface Damage (repair-01) Local blending must extend over area fifteen times the depth of injury. Finish must be as smooth as the original, 72-36+42, rep-01, Fig. 901.
90	27	VERTICAL LATHE	Machine Disk Bore (repair-03) Machine disk bore to 9.005" maximum basic diameter, 9.025" maximum repair diameter. Maintain concentricity and restore corner radii.
100	27	VERTICAL LATHE	Machine Front Spacer Mating Surface (repair-09) Machine spacer mating surface provided base metal thickness is not reduced below minimum dimension given in repair-09, subtask 72-36-41-32-007, Table 901.
110	27	VERTICAL LATHE	Machine Rear Spacer Mating Surface (repair-10) Machine spacer mating surface provided base metal thickness is not reduced below minimum dimension given in repair-10, subtask 72-36-41-32-008, Table 901.
120	27	VERTICAL LATHE	Machine Tierod Holes (repair-04) Machine hone tierod holes showing plating cracks to 0.443"-0.446". Do not increase hole diameter by more than 0.005" maximum. Finish tierod holes per SPOP 502.
130	27	VERTICAL LATHE	Machine Center Rail Face Galling Repair (repair-14) Machine center rail front/rear face to remove all visual indications of galling per 72-36-41, repair-14, subtask 72-36-41-024.
145	614	SUPPT. SHOP PLATING	Nickel Plate Front Snap Diameter (repair-11) Nickel plate the front snap diameter per SPOP 29 to an amount sufficient for final machining. Bake at 350 - 400 degrees for three hours.
147	228	COMPRESSOR MACH. SH	Final Machine Front Snap Diameter (repair-11) Finish machine the front snap diameter to 16.2885" - 16.2905". Maintain 0.020" - 0.030" radius between snap diameter and face of disk. Actual dimension M: _____
150	614	SUPPT. SHOP PLATING	Nickel Plate Rear Snap Diameter (repair-12) Nickel plate the rear snap diameter per SPOP 29 to an amount sufficient for final machining. Bake at 350 - 400 degrees for three

			hours.	
155	228	COMPRESSOR MACH. SH	Final Machine Rear Snap Diameter (repair-12) Finish machine the rear snap diameter to 15.4665" - 15.4685". Maintain 0.020" - 0.030" radius between snap diameter and face of disk. Actual dimension M: _____	
157	610	SUPPT. SHOP GRITBLA	Grit Blast (repair-02) Grit blast disk to remove residual rust per SPOP 218. (Note: Do not blast tierod holes).	
158	256	H/C CELL INSPECTIO	Inspect (repair-02) Inspect prior to Ni-Cad or sermetel for satisfactory condition.	N/A
160	614	SUPPT. SHOP PLATING	Replace Ni-Cad (repair-02) Replace Ni-Cad on the disk as follows, per SPOP 25, and overhaul standard practice manual 70-44-01 page 69. Note: Vinyl gloves must be worn at "ALL" times when handling disk. Note: Operation 1 thru 14 are for stripping the Ni-Cad and Nickel Plate Repairs. 15: Mask as required per SPOP 36 and Attach plating fixture. 16: Alkali clean 1-3 minutes. 17: Clean rinse with room temp. water. 18: Examine for water breaks. If water breaks scrub the area with alkali solution and pumice, then clean water rinse. Recycle part beginning with operation 16. 19: Immerse in acid to etch. 20: Clean rinse with room temp. water.	
180	614	SUPPT.SHOP PLATING	Apply Nickel Plating (repair-02) Reapply Nickel as follows and SPOP 25, per standard practice manual 70-44-01 page 71. 22: Clean rinse with room temp. water. 23: Immerse in nickel plate with the current ON and plate to a thickness of 0.5 Mils - 0.6 Mils Tank #:_____ Tank Temp:_____ 24: Clean rinse with room temp. water. 25: Alkali rinse in PS 52 solution. 26: Clean rinse with room temp. water.	
200	614	SUPPT. SHOP PLATING	Apply Cad Plating (repair-02) Apply Cad plating as follows and SPOP 25 per standard practice manual 70-44-01 page 72. 28: Alkali clean by immersion 29: Clean rinse with room temp. water. 30: Examine for water breaks. If water breaks occure, scrub the area to be plated and troroughly rinse to remove all pumice.	



			<p>31: Immerse in acid to etch.</p> <p>32: Clean rinse with room temp. water.</p> <p>33: Immerse in neutralization solution PS 52, 3% NaOH solution.</p> <p>34: Clean rinse with room temp. water.</p> <p>35: Immerse in cadmium to a total thickness of 0.0001" - 0.0002".</p> <p>Tank #:_____ Tank Temp.: _____</p> <p>36: Clean rinse with room temp. water.</p> <p>37: Clean rinse with room temp. water.</p> <p>38: Remove fixture and masking.</p> <p>39: Immerse in chromate conversion solution PS 36 or PS 56.</p> <p>40: Clean rinse with room temp. water.</p> <p>42: Clean rinse with 120 - 140 degrees water.</p> <p>43: Air dry.</p> <p>Operation 44 thru 44d N/A (Cutback Procedure:)</p> <p>44e: Bake for 60 minutes at 620 - 640 degrees.</p>	
210	614	SUPPT. SHOP PLATING	<p>Inspect NiCad Plating (repair-02)</p> <p>Inspect and record the thickness of the NiCad plating at four locations and record.</p> <p>Plating</p> <p>Location 1 M:_____ Thickness 1 Mils.</p> <p>Location 2 M:_____ Thickness 2 Mils.</p> <p>Location 3 M:_____ Thickness 3 Mils.</p> <p>Location 4 M:_____ Thickness 4 Mils</p> <p>NOTE: The first location will be at the web where the P/N is stamped, and the 3 others will be 90 degrees apart from the first location.</p>	
220	611	SUPPT. SHOP PAINT	<p>Paint Contact Area (s) (repair-02)</p> <p>Paint the contact area(s), where specified, one coat by spraying or brushing per PWA 578.</p> <p>Bake paint at 475 - 525 degrees for 90 minutes.</p>	
230	623	SUPPORT SUBCONTRAC	<p>Subcontract (repair-02)</p> <p>Apply sermetel coat 2241 per PWA 110.</p>	
240	256	H/C CELL INSPECTIO	<p>Inspect (repair-02)</p> <p>Inspect sermetel.</p>	N/A
250	256	H/C CELL INSPECTIO	<p>Final Inspect</p> <p>Visual inspect for satisfactory completeness and sign offs of all routing specified.</p> <p>Record finish snap dimension on DPI Form: AT-56-05.</p> <p>Attach serviceable tag.</p>	N/A

## **Appendix D - Pratt & Whitney Plating Requirements for #7 HPC Disk**

Pratt & Whitney

JT8D ENGINE MANUAL (PN 481672 - RESTRUCTURED)

## **Compressor Disk, Stage 7 - Repair-021. Task 72-36-41-30-002-001: Nickel-Cadimium Plating (Optional To PWA 110)**

### **A. Equipment and Materials Required**

Support Equipment: PWA 33528 Fixture

Consumables: None

Expendable Parts: None

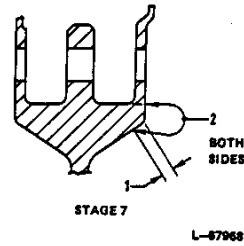
### **B. Procedure**

See [Figure 901](#) and [figure 902](#). For disks with tierod hole bushings, an effective method of preventing corrosion under bushings while stripping or plating nickel-cadmium, is to install locally fabricated rubber washer on each side of tierod hole. See Figure 902. Washers should be approximately 3/8" larger than bushing and extend onto snap face when stripping nickel-cadmium plate. Prior to nickel-cadmium plating, install rubber washers that are approximately 1/4" smaller than the washers used for stripping. Use locally obtainable steel washers, bolt, and nut to secure the rubber washers. **UNDER NO CIRCUMSTANCES IS IT PERMISSIBLE TO REPLACE ONLY THE CADMIUM PORTION OF DIFFUSED NICKEL-CADMIUM PLATE. WHENEVER DIFFUSED NICKEL-CADMIUM PLATE IS TO BE REPLACED, ENTIRE PLATING MUST BE REMOVED, INCLUDING UNDERLYING LAYER OF NICKEL PLATE, TO EXPOSE BASE METAL.**

1. Compressor disks shall be chemically stripped of nickel-cadmium plate and replated as condition of plate warrants. Prior to stripping nickel-cadmium from any disk, inspect tierod holes for cracks, per Task 72-36-41-22-000 (Inspection-01). Tierod holes showing cracks in plating, see Task 72-36-41-30-007 (Repair-04).

**Final & Working Edition  
JTSD ENGINE MANUAL (PN 481672 - RESTRUCTURED)**

**COMPRESSOR DISK, STAGE 7 - REPAIR-02**



1. 0.125 Inch Maximum, Both Sides.
2. Electrical Contact Permissible Only In This Area, Both Sides. No Burning, Pitting, Or Selective Attack Permitted. Completely Cover Contact Points In This Area With FWA 578 Paint After Plating But Before Nickel-Cadmium Plate Baking.

Seventh Stage Disk  
Nickel-Cadmium Plating  
Figure 901  
(Task 72-36-41-30-002)

**CAUTION:** ALL CARRYING AND HANDLING FIXTURES MUST BE MADE OF A RELATIVELY SOFT (ANNEALED) STAINLESS STEEL (ROCKWELL C-25 OR LESS) OR BE COVERED WITH A SOFT MATERIAL. BARE METAL FIXTURES MUST HAVE WELL ROUNDED CORNERS.

Subtask 72-36-41-22-004

- (2) Before removing existing nickel-cadmium plate, carefully measure and record front and rear snap diameters tiered hole centerline in relation to rear snap diameter, and web thickness in area contacted by spacers.

**NOTE:** These measurements are necessary in order that any plated repair, which has been made to disk in areas measured, may be renewed and disk returned to these same dimensions.

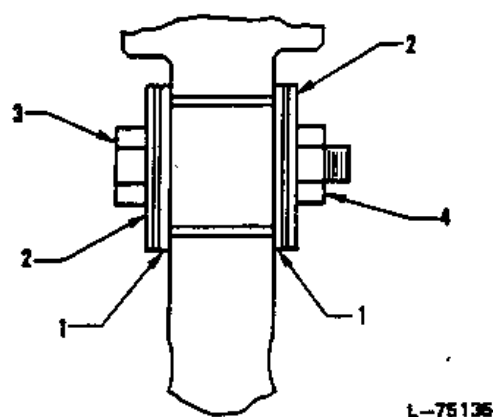
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**COMPRESSOR DISK, STAGE 7 - REPAIR-02**

**Pratt & Whitney Aircraft**  
**JT8D ENGINE MANUAL (PN 481672 - RESTRUCTURED)**  
**COMPRESSOR DISK, STAGE 7 - REPAIR-02**



- 1. Rubber Washer (Two Required)
- 2. Steel Washer (Two Required)
- 3. Bolt
- 4. Nut

**Tierod Hole Protection**

**72**

Subtask 72-36-41-33-005-001

- 2. Strip existing nickel-cadmium plate per SPOP 25 (Subtask 70-00-00-33-005). When stripping plate, note and record presence of plating repairs. All such repair plating must be removed to expose smooth base metal.

Subtask 72-36-41-12-002-001

- 3. Remove any residual rust after stripping nickel-cadmium per SPOP 9 (Subtask 70-00-00-12-002).

## Subtask 72-36-41-22-005

4. Dimensionally inspect after removing old nickel-cadmium plate and any previous plating repairs, measure front and rear snap diameters and tierod holes as specified in step (2). Compare these dimensions with those obtained in step (2) before stripping, in order to determine what plating repairs must be made and to what extent.

## Subtask 72-36-41-22-006

5. Visually inspect all areas of each disk for pitting, galling, or other defects.

## Subtask 72-36-41-24-008

6. Magnetic particle inspect per Task 72-36-00-24-000, (Section 72-36-00, Inspection-02).
7. Inspection is necessary after stripping even though disk may have been inspected previously.
8. IF IT IS NECESSARY TO MACHINE DISK SNAP DIAMETER IN ORDER TO REMOVE UNACCEPTABLE SURFACE CONDITIONS, RESTORE PART TO SAME DIAMETER THAT EXISTED BEFORE REPAIR. MAXIMUM FINISHED PLATING THICKNESS MUST NOT EXCEED 0.010 INCH.
9. Make all necessary blending and machining repairs prior to nickel-cadmium plating. Blended areas must be cleaned in accordance with SPOP 9 (Subtask 70-00-00-12-002).

## Subtask 72-36-41-33-008-001

10. Selectively mask disk per SPOP 36 (Subtask 70-00-00-33-008), leaving exposed all areas necessary for restoration of previous plating or new plating repairs.

## Subtask 72-36-41-33-007-003

11. Nickel plate unmasked areas, per SPOP 29, (Subtask 70-00-00-33-007), to thickness necessary with allowance for machining to required dimensions.

## Subtask 72-36-41-32-001

12. Machine repaired areas to dimensions recorded in step (2). Allowance must be made for thickness of nickel-cadmium plate in order to restore disk to dimension.

Subtask 72-36-41-33-005-002 KEEP ELECTRICAL CONTACT AREAS SMOOTH AND FREE OF FOREIGN SUBSTANCES. KEEP MASKING AND INSULATING COAT INTACT TO PREVENT SEEPAGE AND SUBSEQUENT CONTAMINATION OF SOLUTIONS. UNSATISFACTORY BOND OF NICKEL CADMIUM PLATE MAY RESULT WHERE SEEPAGE HAS OCCURRED. Plating area is 745 square inches. Plating currents are 155 amperes for nickel and 130 amperes for cadmium.

13. Use PWA 33528 Fixture, and nickel-cadmium plate disk as follows:
  - a. Plate entire disk with diffused nickel-cadmium plate per SPOP 25 (Subtask 70-00-00-33-005). Nickel plate must be 0.0004 - 0.0007 inch thick all over and 0.0002 - 0.0007 inch thick in blade retaining pin holes.
  - b. All solutions must be monitored by periodic analyses and necessary action to maintain specified concentrations. The use of solutions which are outside the specified control limits may not give satisfactory results.
  - c. Test panels must be plated with same solutions and procedures used for disks in order to establish and monitor quality of this procedure. See following paragraph.
14. Each operator shall submit following parts for Pratt 6 Whitney Aircraft laboratory analysis: See Section 72-00-00, Repair.

15. Disk samples submitted for approval of nickel-cadmium plate must be plated to overhaul manual thickness requirements (usually 0.0004 to 0.0007 inch). Samples should not be plated to 0.0002 to 0.0004 inch thickness required for test panels and most other parts.

Subtask 72-36-41-38-001-002

16. Paint contact areas left by fixture during plating. Apply high baking heat resistant aluminum enamel after plating.

2. Task 72-36-41-30-002-002: PWA 110 Aluminum Coating (Optional To Nickel-Cadmium Plating)

A. Equipment And Materials Required

Support Equipment: None

Consumables: None

Expendable Parts: None

B. Procedure

See Figure 903.

1. Aluminum coat compressor disk at overhaul if condition of coating warrants.

Subtask 72-36-41-33-005-009

2. Strip nickel-cadmium plated parts per SPOP 25 (Subtask 70-00-00-33-005).

Subtask 72-36-41-11-037-001

3. Strip PWA 110-21 coated parts per SPOP 258 (Subtask 70-00-00-11-037).

Subtask 72-36-41-12-002-002

4. Clean disk per SPOP 9 (Subtask 70-00-00-12-002).

Subtask 72-36-41-24-009

5. Magnetic particle inspect per Task 72-36-00-24-000, (Inspection-02).

1. Task 72-36-41-22-000: Visual/Dimensional Inspection

A. Prerequisites

(1) Magnetic particle inspect per Task 72-36-00-24-000, (Section 72-36-00, Inspection-02). Any indications are cause for rejection. See Figure 801 for important inspection and electrical contact areas.

B. For disk failure, instructions are given in Section 72-00-00, Engine General, Inspection-01.

C. Equipment And Materials Required - None

D. Procedure

Subtask 72-36-41-22-010

1. Visually inspect each disk.

a. At every disk inspection you must carefully examine the very important areas that follow. See Figure 801.

1. Bore

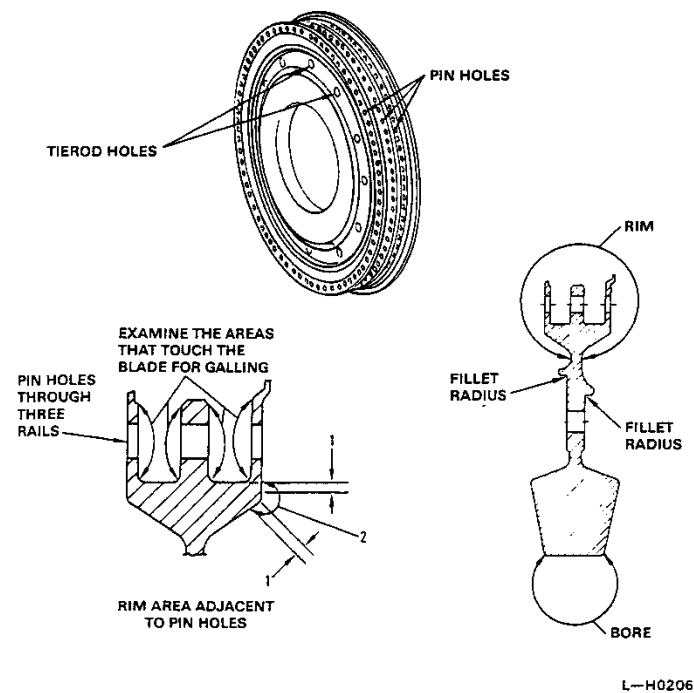
2. Tierod holes

3. Snap diameter (front and rear) fillet radius

4. Pin holes
5. Areas on the rim that touch the blades
6. For very early disks only
  - a. Balance flange
  - b. Balance flange rivet holes
  - b. Use a fluorescent (white) light and 3X magnifying glass to examine for surface damage (such as nicks, dents, scratches, and corrosion pits). Depth of pitting, especially on curved area or areas which are difficult to observe, may be more easily determined by comparison with samples having known by comparison with samples having known pitting depths.
  - c. To ensure that the disk is absolutely clean, it is recommended that the disk be cleaned by the vapor degreasing method immediately prior to inspection.
  - d. To repair corrosion pitting up to 0.010 inch deep in electrical contact areas ([Figure 801](#)), and to complement blend repairs see Task 72-36-41-30-009, (Repair-06).
2. Evaluation of surface should take into consideration need for repairs and limits to which repairs may be made. Some conditions are acceptable without repair. However, it is desirable to blend repair these areas. The sharper the surface damage the more desirable it is to blend area.
3. UNDER NO CIRCUMSTANCES SHALL SNAP DIAMETER OF DISK BE CHANGED, AS EVALUATION OF DISK GROWTH WOULD BE IMPAIRED.
4. Acceptability and reparability of specific area of disk shall be made per Figures 802 and 803. Enclosed areas are to corners, points of tangency between surfaces or at points opposite one of these locations.
  - (a) On 7th stage disks having counterweight flange (Reference PN 500507), visually inspect counterweight holes on balance flange to ensure that no damage exists at edges of holes. If damage is found, disk should be reworked in accordance with SB 2952 entitled "Disk, 7th Stage, with scalloped counterweight flange".
5. All disks which have been subjected to extremely high temperatures (in internal area of compressor and rotor tube area) as evidenced by mottled appearance must be inspected as follows:
6. These special requirements apply only to disks which have been subjected to these conditions.
  - (a) Disk which displays mottled appearance on any portion of its plated surface shall be rejected.



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**JT8D ENGINE MANUAL (PN 481672 - RESTRUCTURED)**  
**COMPRESSOR DISK, STAGE 7 - INSPECTION-01**



1. 0.125 Inch Maximum.
2. Electrical Contact Permissible Only In This Area. No Burning, Pitting, or Selective Attack Permitted.

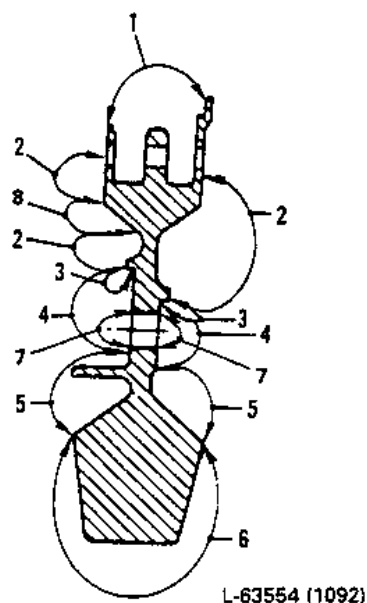
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Important Inspection And  
 Electrical Contact Areas  
 Figure 801  
 (Task 72-36-41-22-000)

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**COMPRESSOR DISK, STAGE 7 - INSPECTION-01**



**Seventh Stage Compressor Disk**

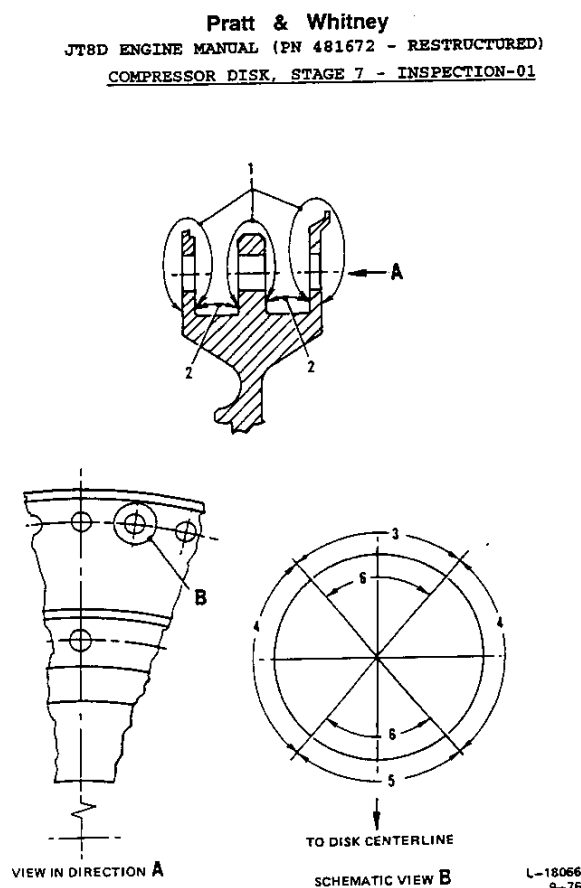
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1. For Limits In Blade Attachment Area See Figure 803.
2. Damage Up To 0.003 Inch Acceptable Without Blending. Blend Repair To Maximum Depth of 0.005 Inch Permissible. Depth of Blends Opposite Each Other Not To Exceed 0.005 Inch Total. No Rub Indications Permitted On Rim.
3. No Unrepaired Damage Allowed. Damage To Snap Diameters Is Repairable to Depth of 0.005 Inch By Local Blending, Or 0.010 Inch By Machining And Plating To Restore Size. No Damage Allowed In Radius Between Web And Snap Diameter Within 0.125 Inch Of Tierod

Hole.

4. Scattered Surface Damage Up To 0.003 Inch Deep Allowed Without Repair, Except No Damage Allowed Within 0.125 Inch of Edge Of Hole On Adjacent Surfaces. Smooth Depressions Made By Mating Parts Up To 0.005 Inch Are Acceptable Without Repair. No Paint Permitted.
5. Scattered Surface Damage Up To 0.003 Inch Deep Allowed Without Repair. Local Blend Permitted To 0.005 Inch Deep, Provided That Depth of Blends Opposite Each Other Do Not Exceed 0.005 Inch Total.
6. No Surface Damage Allowed Without Blending. Local Blend to 0.010 Inch Permitted. Permissible to Machine Bore To Maximum Depth of 0.010 Inch Radially.
7. No Unrepaired Surface Damage Allowed In Any Hole Or Within 0.125 Inch Of Edge Of Hole On Adjacent Surfaces. Repair To Depth Of 0.005 Inch By Blending.
8. Damage Up To 0.003 Inch Acceptable Without Blending. Blend Repair To Maximum Depth of 0.010 Inch Permissible.

Key To Figure 802



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Compressor Disk 7th Stage -  
Pin Joint  
Figure 803  
(Task 72-36-41-22-000)

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**COMPRESSOR DISK, STAGE 7 - INSPECTION-01**

1. NO Unrepaired Damage Is Allowed Except Galling On Rear Face Of Center Rim To Maximum Of 0.010 Inch Deep. May Be Blended Up To 0.005 Inch Deep Except OD Of Front And Center Rails. Damage on OD Of Front And Center Rails May Be Blended Up To 0.030 Inch Deep Provided Damage Is Not Within 1/4 Inch Of Radial Centerline Of Pinholes.
2. Scattered Surface Damage Up To 0.003 Inch Deep is Acceptable Without Repair. May Be Blend Repaired Up To 0.005 Inch Deep.
3. Scattered Surface Damage UP to 0.005 Inch Deep Is Acceptable Without Repair. Damage Exceeding 0.003 Inch May Not Be Blended. See Task 74-36-41-30-001, (Repair-01).
4. Scattered Surface Damage Up To 0.003 Inch Deep Is Acceptable Without Repair. Damage Up To 0.005 Inch Deep May Be Blend Repaired.
5. No Unrepaired Surface Damage Is Allowed In Hole Of Hole To Face Radius. Damage Up To 0.005 Inch Deep May Be Blend Repaired.
6. 90° - 110°

#### Key to Figure 803

- a. Disk having bore dimension measuring more than 0.004 inch over maximum basic dimension, shall be rejected.
  - b. Disk having snap diameter measuring more than 0.008 inch over maximum basic dimension shall be rejected. [See Table 801.](#)
  - c. No unrepaired damage permitted on snap diameters. Damage to snap diameters is reparable to depth of 0.05 inch by local blending, or 0.010 inch by machining and plating to restore size. No damage allowed in radius between web and snap diameter within 0.125 inch of tierod hole.
  - d. Disk which is found, by taking superficial Rockwell A scale hardness measurement, to have greater hardness at rim than at bore shall be rejected. (Hardness test marks must be polished smooth on serviceable disks.)
- E. Perform thorough visual inspection for rub indications on disk rim. If rub indications appear on both sides of disk rim, disk must be scrapped. If rub indications appear on only one side of disk rim, blend per Task 72-36-41-30-001, (Repair-01).
- F. A ripple observed in web or in surface between bore and snap does not cause a material reduction in thickness and is acceptable.

#### Table 801

##### 7th Stage Disk

##### Maximum Basic Dimension (Inches)

Front Snap	16.291
Rear Snap	15.469

#### Subtask 72-36-41-22-011

#### G. Service Marking

- a. Inspect each disk for markings.
- b. Marking in areas other than disk OD tang and disk rim are unacceptable. Such areas must be blended out and remarked in acceptable area. [See Figure 804.](#)
- c. Use manual vibration peening method for permanent marking. See Standard Practices Manual.

## Subtask 72-36-41-22-012

## H. Service life

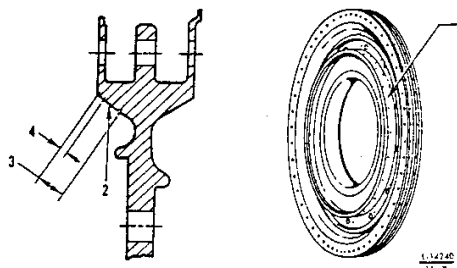
- a. See Time Limits for disk life.
- b. RECORDS SHOULD BE CONTINUOUSLY CHECKED TO ENSURE THAT SPECIFIED SERVICE LIFE WILL NOT BE EXCEEDED.
- c. Maintain complete and accurate record of total service time of each disk.

## Subtask 72-36-41-22-013

## I. Snap Diameters

J. Records must be maintained on snap diameters so that total disk growth may be known. If snaps are repaired back within original tolerance, old growth plus new dimension must be recorded in order that further growth may be accounted for an totaled.

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**JT8D ENGINE MANUAL (PN 481672 - RESTRUCTURED)**  
**COMPRESSOR DISK, STAGE 7 - INSPECTION-01**



1. Service Time Marking Area, Outboard Side Only
2. Service Time Marking Area For Disks Without Counter Weight Flange.
3. 0.400 Inch Maximum
4. 0.100 Inch Minimum

Disk Marking (Stage 7)  
 Figure 804  
 (Task 72-36-41-22-000)

- (a) Measure and record snap diameters.
  - (b) Check records for previous growth and repair.
  - (c) Establish total amount of growth on disk.
1. Reject any disk whose growth exceeds "replace" dimension given in Section 72-36-00, Inspection-03.

**NOTE:** Disks whose snap diameters do not exceed "replace" dimension may be repaired back to basic dimensions if necessary. However, check of mating spacer snap diameters is necessary to indicate whether their corresponding growth and otherwise acceptable condition precludes this repair of disk. Also spacer and adjacent disk tiered holes should be checked to see

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- a. Measure and record snap diameters.
- b. Check records for previous growth and repair.

- c. Establish total amount of growth on disk.

1 Reject any disk whose growth exceeds "replace" dimension given in Section 72-36-00, Inspection-03. Disks whose snap diameters do not exceed "replace" dimension may be repaired back to basic dimensions if necessary. However, check of mating spacer snap diameters is necessary to indicate whether their corresponding growth and otherwise acceptable condition precludes this repair of disk. Also spacer and adjacent disk tierod holes should be checked to see whether growth has affected tierod bolt circle and whether tierods would not be freely accepted when rotor is stacked. Such a condition might preclude repair of disk.

**EXISTING DISK TIEROD HOLES CANNOT BE ALTERED TO CHANGE EXISTING BOLT HOLE CIRCLE DIAMETER.**

Subtask 72-36-41-22-014

#### K. Tierod Holes

- a. Using 20X magnifying glass, inspect each tierod hole for cracks in nickel-cadmium plate. Disks with visible cracks in plate are to be magnetic particle inspected per Standard Practices Manual.
- b. If magnetic particle inspection of tierod holes does not show signs of cracks in parent metal, proceed with removal and replacement of nickel-cadmium plate per Task 72-36-41-30-002, (Repair-02). Disk which is found to have cracks in parent metal shall be rejected and held for future disposition.
- c. All tierod holes may be up to 0.005 inch over maximum ID.
- d. See Section 72-00-00, Inspection-01 and 72-36-00, Inspection-03 for additional relaxed tierod hole limits. As indicated, tierod holes may be up to 0.008 inch oversize provided quantity and position of holes is as stated.

Subtask 72-36-41-22-018

- L. Inspect disk tierod holes for excess wear. Repair worn tierod holes per Task 72-36-41-30-016 (Repair-13).

## Appendix E-Examples of THY Repair Station Operations Specifications Specifications

UNITED STATES OF AMERICA  
DEPARTMENT OF TRANSPORTATION  
FEDERAL AVIATION ADMINISTRATION

### Air Agency Certificate

Number 820-17

*This certificate is issued to*

TURKISH AIRLINES, INCORPORATED  
*whose business address is*  
YESIRKÖY INTERNATIONAL AIRPORT  
ISTANBUL, TURKEY

*upon finding that its organization complies in all respects with the requirements of the Federal Aviation Regulations relating to the establishment of an Air Agency, and is empowered to operate an approved* REPAIR STATION

*with the following ratings:*

AIRFRAME  
POWERPLANT  
INSTRUMENT  
ACCESSORY  
RADIO  
LIMITED SPECIALIZED SERVICE

*This certificate, unless canceled, suspended, or revoked, shall continue in effect* UNTIL MAY 15, 1986

Date issued:

MARCH 8, 1976

*Signature of the Administrator*

*W. L. CHERRY*

MANAGAN, INTERNATIONAL FIELD OFFICE #51

This Certificate is not Transferable, and any major change in the basic facilities, or in the location thereof, shall be immediately reported to the appropriate regional office of the Federal Aviation Administration.

Any alteration of this certificate is punishable by a fine of not exceeding \$1,000, or imprisonment not exceeding 3 years, or both.

FAA Form 8080-6 (1-67) SUPERSEDES FAA FORM 200.

UNITED STATES OF AMERICA  
DEPARTMENT OF TRANSPORTATION  
FEDERAL AVIATION ADMINISTRATION

## Repair Station Operations Specifications

(Continuation)

### Limitations:

The rating (s) set forth on the Agency Certificate Number 820-17 is (are) limited to the following:

AIRFRAME	CLASS 4	INSTRUMENT	CLASS 1, 2, 3 & 4
POWERPLANT	CLASS 1	ACCESSORY	CLASS 1, 2 & 3
RADIO	CLASS 1, 2 & 3		

### LIMITED RATINGS

### SPECIALIZED SERVICE

NON-DESTRUCTIVE TESTING      ULTRASONIC, MAGNETIC PARTICLE  
EDDY CURRENT,  
PENETRANT-VISIBLE DYE & FLUORESCENT DYE  
RADIOGRAPHIC X-RAY  
METAL PLATING

EMERGENCY EQUIPMENT      LIFE PRESERVERS: AIR CRUISERS - ALL MODELS  
AMERICAN SAFETY - ALL MODELS  
LIFE RAFTS: AIR CRUISERS - ALL MODELS  
AMERICAN SAFETY - ALL MODELS  
SLIDE CHAIRS: AIR CRUISERS - ALL MODELS  
AMERICAN SAFETY - ALL MODELS

THE ABOVE SPECIALIZED SERVICES SHALL BE PERFORMED IN ACCORDANCE WITH THE PRODUCT MANUFACTURER'S CURRENT INSTRUCTIONS AND SPECIFICATIONS, FAA ADVISORY CIRCULARS, THE CUSTOMER'S FAA APPROVED SPECIFICATIONS OR OTHER FAA APPROVED DATA.

Delegated authority: NONE

Date issued or revised:

MAY 22, 1984

W. L. CHORY

MANAGER, INTERNATIONAL FIELD OFFICE #51

FAA Form 8000-4-1 (10-78)

FORMERLY FAA FORM 100.1 PAGE 2

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Repair Station Operations Specifications



# Air Agency Certificate

Number 820-1F

*This certificate is issued to*

**TURKISH AIRLINES, INCORPORATED**

whose business address is

YESILKÖY INTERNATIONAL AIRPORT  
İSTANBUL, TURKEY

upon finding that its organization complies in all respects with the requirements of the Federal Aviation Regulations relating to the establishment of an Air Agency, and is empowered to operate an approved

REPAIR STATION

with the following ratings:

### ACCESSORY

### **INSTRUMENT**

## RADIO

LIMITED AIRFRAME (11/21/86)

LIMITED POWERPLANT (11/21/86)

LIMITED SPECIALIZED SERVICE

*This certificate, unless canceled, suspended, or revoked,  
shall continue in effect* UNTIL NOVEMBER 23, 1987

UNTIL NOVEMBER 23, 1987

*Deus in excelsis*

MARCH 8, 1974

By direction of the Administrator

*H. L. Enery*  
H. L. ENERY

MANAGER, INTERNATIONAL FIELD OFFICE /51

**The Contractor is Not Transferrable, and any major change in the basic facilities, or in the location thereof, shall be immediately reported to the appropriate regional office of the Federal Inflation Administration.**

[illegible]

FAA Form 2800-4 (1-67) SUPERSEDES FAA FORM 290.

## Air Agency Certificate

UNITED STATES OF AMERICA  
DEPARTMENT OF TRANSPORTATION  
FEDERAL AVIATION ADMINISTRATION

## Repair Station Operations Specifications

(Continuation)

### Limitations:

The rating(s) set forth on the following Certificate Number 920-1F is/are limited to the following:

ACCESSORY	CLASS 1, 2, 3
INSTRUMENT	CLASS 1, 2, 3, 4
RADIO	CLASS 1, 2, 3

### LIMITED RATINGS

AIRFRAME	AIRBUS INDUSTRIES	A300 SERIES, A310 SERIES
	BECH AIRCRAFT	100 SERIES, 200 SERIES
	BOEING AIRPLANE CO.	B707/720 SERIES, B727 SERIES
	FOKKER	F28 SERIES
	GULFSTREAM AEROSPACE	G1199 SERIES
	MCDONNELL DOUGLAS	DC-9 SERIES, DC-10 SERIES

LINE MAINTENANCE FOR OTHER AIRCRAFT IN THE CLASS 4 CATEGORY INCLUDES MINOR INSPECTIONS, MINOR MAINTENANCE AND REPAIRS, MINOR ALTERATIONS AND CORRECTION OF PILOT WRITE UPS.

POWERPLANT	GENERAL ELECTRIC	CF6 SERIES
	PRATT AND WHITNEY	JT3D SERIES, JT9D SERIES, JT9D SERIES AND PT6A SERIES
	ROLLS ROYCE	SPEY RB 211 SERIES
		SPEY RB 511 SERIES
		SPEY MK 555 SERIES

LINE MAINTENANCE FOR OTHER ENGINES IN THE CLASS 3 CATEGORY. AUTHORIZATION IS LIMITED TO MINOR INSPECTIONS, REMOVAL/INSTALLATION OF ACCESSORIES AND COMPONENTS, ADJUSTMENTS, MINOR REPAIRS, MINOR ALTERATIONS ONLY. WORK TO BE ACCOMPLISHED IN ACCORDANCE WITH THE MANUFACTURER'S CURRENT TECHNICAL DATA OR OTHER PROCEDURES ACCEPTABLE TO THE ADMINISTRATOR.

Delegated authorities: NONE

Date issued or revised:

NOVEMBER 21, 1986

FAA Form 8000-2-1 (11-79)

*For Administrator*  
*Clarence H. Wise*  
CLARENCE H. WISE  
SUPERVISOR, AIRWORTHINESS UNIT

FORMERLY FAA FORM 330.1 PAGE 2

Repair Station Operation Specifications

UNITED STATES OF AMERICA  
DEPARTMENT OF TRANSPORTATION  
FEDERAL AVIATION ADMINISTRATION

## Repair Station Operations Specifications

(Continuation)

Limitations:

The rating (s) set forth on the Agency Certificate Number 820-1F is/are limited to the following:

LIMITED RATINGS (CONTINUED)

SPECIALIZED SERVICE

NON-DESTRUCTIVE TESTING	ULTRASONIC, MAGNETIC PARTICLE PER MIL-I-29133 AND 6868E AS REVISED EDDY CURRENT, PER MIL-STD-1937 AS REVISED PENETRANT-VISIBLE DYE & FLUORESCENT DYE PER MIL-I-6868 AS REVISED. RADIOGRAPHIC X-RAY PER MIL-STD 00453 AS REVISED
EMERGENCY EQUIPMENT	LIFE PRESERVERS: AIR CRUISERS - ALL MODELS AMERICAN SAFETY - ALL MODELS LIFE RAFTS: AIR CRUISERS - ALL MODELS AMERICAN SAFETY - ALL MODELS SLIDE CHUTES: AIR CRUISERS - ALL MODELS AMERICAN SAFETY - ALL MODELS

THE ABOVE SPECIALIZED SERVICES SHALL BE PERFORMED IN ACCORDANCE WITH THE PRODUCT MANUFACTURER'S CURRENT INSTRUCTIONS AND SPECIFICATIONS, FAA ADVISORY CIRCULARS, THE CUSTOMER'S FAA APPROVED SPECIFICATIONS OR OTHER FAA APPROVED DATA.

Delegated authorities: NONE

Date issued or revised:

NOVEMBER 21, 1986

FAA Form 8080-4-1 (11-79)

FORMERLY FAA FORM 302.1 PAGE 2

*For the Administrator*  
*Lawrence M. Vise*  
LAWRENCE M. VISE  
SUPERVISOR, AIRWORTHINESS UNIT

UNITED STATES OF AMERICA  
DEPARTMENT OF TRANSPORTATION  
FEDERAL AVIATION ADMINISTRATION

## Air Agency Certificate

Number TQKY144F

*This certificate is issued to*

TURKISH AIRLINES, INCORPORATED

*whose business address is*

ATATURK INTERNATIONAL AIRPORT  
ISTANBUL, TURKEY

*upon finding that its organization complies in all respects  
with the requirements of the Federal Aviation Regulations  
relating to the establishment of an Air Agency, and is  
empowered to operate an approved* REPAIR STATION

*with the following ratings:*

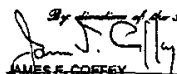
LIMITED AIRFRAME (8/4/84)  
LIMITED POWERPLANT (8/4/84)  
LIMITED RADIO (8/31/81)  
LIMITED INSTRUMENT (8/31/81)  
LIMITED ACCESSORY (8/31/81)  
LIMITED SPECIALIZED SERVICE (8/4/84)  
LIMITED EMERGENCY EQUIPMENT (8/4/84)

*This certificate, unless canceled, suspended, or revoked,  
shall continue in effect* UNTIL AUGUST 31, 1988

Date issued:

MARCH 8, 1974

*By direction of the Administration*



JAMES F. CORREY  
MANAGER, INTERNATIONAL FIELD OFFICE

THIS CERTIFICATE IS NOT TRANSFERABLE, AND ANY MAJOR CHANGE IN THE BASIC FACILITIES, OR IN THE LOCATION THEREOF,  
SHALL BE IMMEDIATELY REPORTED TO THE APPROPRIATE REGIONAL OFFICE OF THE FEDERAL AVIATION ADMINISTRATION.

THIS CERTIFICATE IS NOT TRANSFERABLE, AND ANY MAJOR CHANGE IN THE BASIC FACILITIES, OR IN THE LOCATION THEREOF, SHALL BE IMMEDIATELY REPORTED TO THE APPROPRIATE REGIONAL OFFICE OF THE FEDERAL AVIATION ADMINISTRATION.

FAA Form 8008-4 (1-47) SUPERSEDES FAA FORM 890.

Air Agency Certificate

UNITED STATES OF AMERICA  
DEPARTMENT OF TRANSPORTATION  
FEDERAL AVIATION ADMINISTRATION

## Repair Station Operations Specifications

(Continuation)

Limitations:

PAGE 1 OF 5

The ratings (s) set forth on this Agency Certificate Number TQKY144F is/are limited to the following:

LIMITED RATINGS:

AIRFRAME

AIRBUS INDUSTRIES	-MODEL A310 & A340 SERIES
BEECH AIRCRAFT	-MODEL 200 SERIES
BOEING AIRPLANE CO.	-MODEL B707/720, B727 & B737 SERIES
FOKKER	-MODEL F28 SERIES
GULFSTREAM AEROSPACE	-MODEL G IV
MCDONNELL DOUGLAS	-MODEL DC-9 SERIES, DC-10 SERIES

LIMITED TO MAINTENANCE, PREVENTIVE MAINTENANCE AND INSPECTIONS UP TO AND INCLUDING "D" CHECKS OR EQUIVALENT AND RELATED MAINTENANCE. THIS DOES NOT AUTHORIZE OVERHAUL OR REPAIR OF COMPONENTS, ACCESSORIES AND/OR APPLIANCES EXCEPT WITHIN THE LIMITATIONS OF THE RATING.

POWERPLANT

GENERAL ELECTRIC	-CF6 & CF6-80 SERIES
PRATT AND WHITNEY	-JT3D, JT8D, JT9D, & PT6A SERIES

POWERPLANT AUTHORIZATION FOR THE AFOREMENTIONED ENGINES INCLUDES MAINTENANCE AT ALL LEVELS UP TO AND INCLUDING OVERHAUL IN ACCORDANCE WITH CURRENT MANUFACTURER'S MAINTENANCE MANUALS OR OTHER FAA APPROVED DATA.

Delegated authority: NONE

Date issued or revised:

For the Substantiation:

AUGUST 4, 1994

ROY C. MENARD  
AVIATION SAFETY INSPECTOR

FAA Form 8000-4-1 (1-1-78)

FORMERLY FAA FORM 100.3 PAGE 2

U.S.GPO 1992 O-986-770

Repair Station Operations Specifications

UNITED STATES OF AMERICA  
DEPARTMENT OF TRANSPORTATION  
FEDERAL AVIATION ADMINISTRATION

# Repair Station Operations Specifications

(Continuation)

*Limitations:*

PAGE 2 OF 5

The ratings (x) set forth on the Agency Certificate Number TOKY144F are limited to the following:

POWERPLANT (CONT.)

MAINTENANCE (EXCLUDING OVERHAUL) IS LIMITED TO ENGINES INSTALLED ON AIRCRAFT LISTED IN THE AIRFRAME RATINGS AND FURTHER LIMITED TO THOSE MAINTENANCE FUNCTIONS AS AUTHORIZED BY THE CURRENT MANUFACTURER'S MAINTENANCE OR FAA APPROVED DATA.

ACCESSORY  
INSTRUMENT  
RADIO

AUTHORIZATIONS ARE LIMITED TO COMPONENTS AS LISTED IN TURKISH AIRLINES CAPABILITY LIST, DOCUMENT TK-CAPLS, DATED JULY 1, 1991, AS REVISED. THE PERFORMANCE OF MAINTENANCE, PREVENTIVE MAINTENANCE, TO INCLUDE MAJOR OVERHAUL AND MAJOR REPAIRS. WORK TO BE ACCOMPLISHED IN ACCORDANCE WITH THE MANUFACTURER'S CURRENT TECHNICAL DATA OR OTHER PROCEDURES ACCEPTABLE OR APPROVED BY THE ADMINISTRATOR.

*Delegated authorities:* NONE

*Date issued or revised:*

*For the Administrator:*

AUGUST 4, 1994

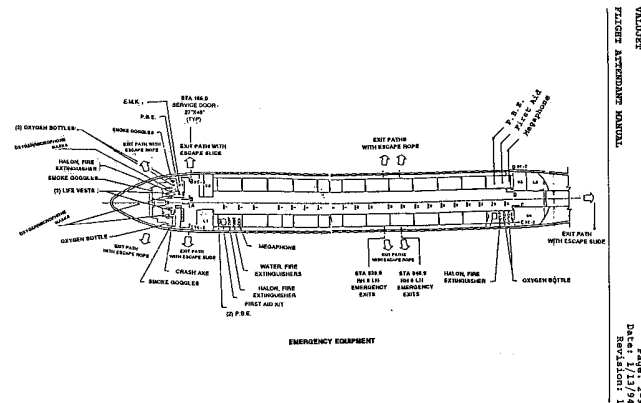
ROY C. MENARD  
AVIATION SAFETY INSPECTOR

FAA Form 8000-4-1 (1-75)

FORMERLY FAA FORM 350-1 PAGE 2

U.S. GPO: 1962-0-868-770

**Before and After Revision in November 11, 1995**



## VALUJET

Page: 3-19

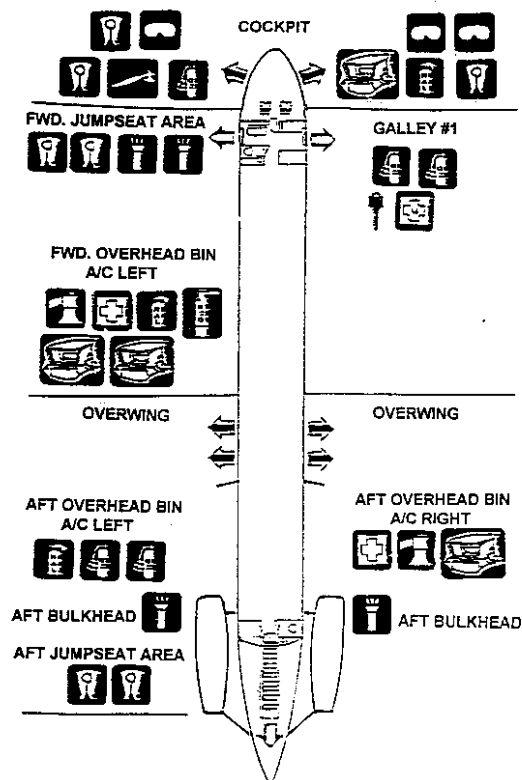
Date: 11/11/95

FLIGHT ATTENDANT MANUAL

Revision: 5

### 3.21 LOCATION OF EQUIPMENT ON AIRCRAFT

### 3.21.1 A/C #901-907, 909-923, 965



**LOCATION OF EQUIPMENT ON AIRCRAFT**



## Appendix G - Comparison of Requirements for Domestic and Foreign Repair Stations Certificated Under FAR Part 145

	DOMESTIC	FOREIGN
Ratings	<ul style="list-style-type: none"> <li>• Ratings are issued for "classes" of items within the following categories: Airframe, Powerplant, Propeller, Radio, Instrument, and Accessory. [Example: a "Class 2" Powerplant rating authorizes the repair station to work on reciprocating engines of more than 400 horsepower; a "Class 3" Powerplant rating authorizes the repair station to work on Turbine engines.] (145.31)</li> <li>• Limited ratings may be issued for a particular make or model within a class of airframe, powerplant, propeller, radio, instrument or accessory, or for other specialized services. (145.33).</li> </ul>	<ul style="list-style-type: none"> <li>• Same as Domestic</li> </ul>
Housing and facility requirements	<ul style="list-style-type: none"> <li>• Must provide suitable housing, space, and facilities to protect work and workers. Detailed requirements for segregation of equipment and functions, appropriately organized storage areas, lighting requirements, etc. (145.35)</li> <li>• Additional requirements for housing of airframes, suitable means for segregating engines or accessory assemblies, storage of propellers, and protection of radio and instrument parts. (145.37)</li> </ul>	<ul style="list-style-type: none"> <li>• Same as Domestic.</li> </ul>
Inspection systems	<ul style="list-style-type: none"> <li>• Must have an inspection system that will produce satisfactory quality control. Detailed requirements for qualifications of inspection personnel. Detailed requirements for inspection systems. Must maintain a manual containing inspection procedures. (145.45)</li> </ul>	<ul style="list-style-type: none"> <li>• Same as Domestic.</li> </ul>
Equipment and materials	<ul style="list-style-type: none"> <li>• Must have equipment and materials necessary to competently and efficiently perform functions appropriate to the ratings and classes sought. Detailed and specific requirements are set forth (145.47 and .49)</li> </ul>	<ul style="list-style-type: none"> <li>• Same as Domestic.</li> </ul>
Performance standards	<ul style="list-style-type: none"> <li>• Must abide by maintenance regulations in FAR Part 43. Must maintain manufacturers manual,</li> </ul>	<ul style="list-style-type: none"> <li>• Same as Domestic.</li> </ul>

	instructions, and bulletins.	
Work for Part 121 operators	<ul style="list-style-type: none"> <li>• Must abide by requirements of carrier's continuing airworthiness program, and work must be in accordance with carrier's manual. (145.2)</li> </ul>	<ul style="list-style-type: none"> <li>• Same as Domestic.</li> </ul>
Inspection of work performed	<ul style="list-style-type: none"> <li>• Before approving an item for return to service, must be inspected by qualified inspector and must certify on maintenance record that it is airworthy with respect to the work performed. (145.49)</li> </ul>	<ul style="list-style-type: none"> <li>• Same as Domestic.</li> </ul>
Inspection by FAA	<ul style="list-style-type: none"> <li>• Must allow FAA to inspect (for adequacy of inspection system, records, and general ability to comply with Part 145) at any time. FAA will notify repair station of defects found. (145.23)</li> </ul>	<ul style="list-style-type: none"> <li>• Same as Domestic.</li> </ul>
Issuance of Certificate	<ul style="list-style-type: none"> <li>• Application must include copy of inspection procedures manual, and list of maintenance functions to be "contracted out".</li> <li>• Applicant who meets requirements of Part 145 is "entitled" to a certificate. (145.11)</li> </ul>	<ul style="list-style-type: none"> <li>• In addition to information required by 145.11, must submit brochure describing facilities, inspection system, organizational chart, names/titles of supervisory personnel, and list of functions to be "contracted out" and contractor names. (145.13)</li> <li>• Applicant must also show that the certificate "will be necessary for maintaining U.S. registered aircraft or parts. (145.71)</li> </ul>
Duration of Certificate	<ul style="list-style-type: none"> <li>• Does not have to be renewed. (145.17)</li> </ul>	<ul style="list-style-type: none"> <li>• Must be renewed within 12 months of initial issuance, and every 24 months thereafter. (145.17)</li> </ul>
Privileges of certificate	<ul style="list-style-type: none"> <li>• May maintain/alter and approve for return to service any aircraft or part for which it is rated. (145.51)</li> </ul>	<ul style="list-style-type: none"> <li>• Same as domestic, but limited to U.S. registered aircraft or parts. (145.73)</li> </ul>
Personnel requirements (including certification)	<ul style="list-style-type: none"> <li>• Must have enough personnel to keep up with volume of work</li> <li>• All supervisory and inspection personnel must be FAA-certified as mechanics or repairmen.</li> <li>• Personnel directly in charge of</li> </ul>	<ul style="list-style-type: none"> <li>• Must have enough personnel to keep up with volume of work.</li> <li>• No personnel are required to have</li> </ul>

	<p>maintenance functions must have 18 months of practical experience in the applicable procedures</p> <ul style="list-style-type: none"> <li>• For each rating, must have employees with detailed knowledge of applicable maintenance functions/techniques based on attending factory school or long experience.</li> <li>• Must document and update work history and experience of all supervisory and inspection personnel.</li> </ul> <p>(145.39, .41 and .43)</p>	<p>FAA (or any) certification.</p> <ul style="list-style-type: none"> <li>• Supervisors and inspectors must be able to read, write, and understand English, and must show they understand the FARS and manufacturer's instructions.</li> </ul> <p>(145.75)</p>
Record-keeping	<ul style="list-style-type: none"> <li>• Must maintain "adequate records of all work that it does," including names of mechanics and inspectors, for 2 years.</li> </ul> <p>(145.61)</p>	<ul style="list-style-type: none"> <li>• Exempt from 145.61</li> <li>• But must maintain records of all maintenance/alteration done on U.S. registered aircraft [no time period specified], and any other records the FAA "finds necessary."</li> </ul> <p>(145.79)</p>
Reports of unairworthy conditions	<ul style="list-style-type: none"> <li>• Must report defects and unairworthy conditions to FAA within 72 hours of discovery</li> </ul> <p>(145.63)</p>	<ul style="list-style-type: none"> <li>• Same as Domestic, but reporting requirement only applies to U.S. registered aircraft.</li> </ul> <p>(145.79)</p>

<sup>1</sup>Unless otherwise indicated, all times are eastern standard time, based on a 24-hour clock.

<sup>2</sup>The Lockheed P-3 is a Navy antisubmarine patrol plane equipped with four turbopropeller engines.

<sup>3</sup>See section 1.17.1 discussed later in this report.

<sup>4</sup>An emergency floor path proximity lighting system was not required when the DC-9 was introduced into service. Subsequently, Federal regulations required transport-category airplanes in commercial passenger service to be so equipped. Therefore, emergency lighting systems were installed in accordance with supplemental type certificates that were approved by the Federal Aviation Administration (FAA).

<sup>5</sup>The first three items on the checklist are (1) setting the parking brakes, (2) retracting the spoilers, and (3) lowering the flap handle.

<sup>6</sup>No chimes were recorded on the CVR. A review of available information, including the CVR transcript and maintenance records, provided no evidence that the interphone was inoperative.

<sup>7</sup>Title 14 CFR Part 139 requires, for scheduled air carrier service with aircraft at least 200 feet in length, that at a minimum the airport be equipped with at least three ARFF vehicles with at least 6,000 gallons of water for foam production.

<sup>8</sup>The Safety Board generally uses the following criteria to assess the quality of a CVR recording: a "poor" recording is one in which a transcription is nearly impossible given that a large portion of the recording is unintelligible; a "fair" recording is one in which a transcription is possible, but the recording is difficult to understand; a "good" recording is one in which few words are unintelligible; and an "excellent" recording is very clear and easily transcribed.

<sup>9</sup>All clock references to the engine or the airplane are as viewed from aft, looking forward.

<sup>10</sup>A substantial portion of the disk was not recovered.

<sup>11</sup>The cooler box, which is a cube-shaped metal container that has an insulated plastic liner, holds canned beverages in ice cubes. It is located on the forward side of the gallery at floor level.

<sup>12</sup>Activation of the engine fire handles will silence the fire warning bell, secure fluid supply valves to the engines, and select the fire suppression bottles. Subsequently turning the handles either clockwise or counterclockwise will discharge the respective bottles.

<sup>13</sup>AeroThrust Corporation is an FAA-certificated repair station, and was one of the vendors used by ValuJet at that time for the repair and overhaul of JT8D engines. Air New Zealand, (located in New Zealand) also an FAA-certificated repair station, was another vendor used by ValuJet for engine repair and overhaul of its JT8D engines.

<sup>14</sup>The cycle life limit for the 7<sup>th</sup> stage disk SN G78851 was prorated from 20,000 cycles to 18,932 cycles, per P&W procedures, because it had been previously operated in a higher-rated JT8D-15 engine.

<sup>15</sup>Holes placed midway between the tierod holes to redistribute the stress in the web area between the tierod holes.

<sup>16</sup>The disk is plated with a nickel cadmium (Ni-Cad) coating for corrosion protection during original manufacture. It is also required to be chemically stripped

and re-plated during certain inspections and repairs.

<sup>17</sup>The consultant who became the primary manager had worked either as an employee or consultant for several operators in the past. While working for these operators, he had at different times been responsible for writing FAA-approved maintenance programs, developing/managing a Part 121 aircraft acceptance program, directing a passenger-to-freighter aircraft configuration conversion program, directing a cockpit/avionics standardization program, developing several large aircraft FAA-approved supplemental type certificates, and developing the guidelines for the DC-9 Structural Inspection Document program for the Douglas Aircraft Company.

<sup>18</sup>This manual provides guidance on performing flight tests in a manner to demonstrate that the aircraft are airworthy and that their systems are fully operational in accordance with their intended use.

<sup>19</sup>This preservation process included purging the fuel system with mineral oil, installing desiccant and humidity indicators inside the engine, and covering the intake, exhaust, and exhaust breather outlet with appropriate covers.

<sup>20</sup>"Serviceable tags" are a commonly used method for repair stations to attach a written maintenance release containing the information specified in FAR 43.9 to an aviation product to show that it is approved for return to service.

<sup>21</sup>FAA Order 8300.10 (Airworthiness Inspector's Handbook), Bulletin A-92-04 (Current FAA Policy Regarding Aircraft Records), dated 7/17/92, states that if an aircraft is being transferred from a foreign airline, it may be necessary to evaluate the foreign operator's maintenance and recordkeeping system to ensure the source validity of the records. The bulletin provides a number of recommendations for determining the validity of the records, which then become the basis for confidence in the current status of life-limited parts and AD compliance.

<sup>22</sup>Deregistration is required by FAR 47.37. See also FAA Order 8130.2C, Chapter 6, Section 2.

<sup>23</sup>Title 14 CFR Part 21.175 requires airworthiness certificates for aircraft. An airworthiness certificate is not required for unmounted engines or spare parts.

<sup>24</sup>Build records are documents specific to each engine in which all component part numbers, SNs, certain measurements, fits, and clearances or other special requirements are recorded in order of assembly.

<sup>25</sup>Such documents, typically known as "shop travelers" or "process sheets," break down the overhaul and inspection process of a component into individual tasks, which include excerpts or references to the appropriate manual, service bulletin, or job instruction card and a signature block for the technician or inspector performing the task. (Hereinafter referred to as "process sheets" or similar documentation.)

<sup>26</sup>The Director of THY's overhaul shop was contacted by the Safety Board after the Safety Board obtained information that P&W had conducted an engine shop maintenance review of THY in December 1991. See Section 1.17.5.1 later in this report for more details regarding that review.

<sup>27</sup>Magnetic particle inspection (MPI) is a nondestructive method of detecting cracks and other defects in ferromagnetic materials such as iron or steel. The inspection consists of magnetizing the part with high amperage DC electricity thus creating magnetic lines of flux, then applying or immersing the part in a liquid containing ferromagnetic particles in suspension. The ferromagnetic particles align themselves with the magnetic lines of flux on the surface of the part forming a pattern. If a discontinuity is present in the material on or near the surface, opposing magnetic poles form on either side of the discontinuity and the pattern is disrupted, forming an "indication." The indication assumes the approximate shape of the surface projection of the discontinuity; however, indications are more visible when the defects are approximately perpendicular to the magnetic lines of flux. As a result, it may be necessary to magnetize in more than one direction to reveal defects aligned parallel to the magnetic lines of flux. The effectiveness of the MPI also depends on the flux density or field strength at the surface of the part when the indicating medium is applied. As the flux density is increased, the sensitivity increased. However, excessively high flux densities may form non-relevant indications.

<sup>28</sup>FMPI is similar to an MPI except the ferromagnetic particles held in suspension are fluorescent such that surface flaw indications luminesce under black light inspection.

<sup>29</sup>Hidden lines, which depict the edges of a smaller feature located behind the larger feature, are shown on orthographic projections as dashed lines.

<sup>30</sup>See 14 CFR Section 43.5 (Approval for return to service after maintenance, preventative maintenance, rebuilding, or alteration.); Section 43.9 (Content, form, and disposition of maintenance, preventative maintenance rebuilding, and alteration records.); and Section 43.7 (Persons authorized to approve aircraft, airframes, aircraft engines, propellers, appliances, or component parts for return to service after maintenance, preventative maintenance, rebuilding, or alteration.); and Section 145.51 (Privileges of repair station certificate.).

<sup>31</sup>Title 14 CFR Part 145.59 (a) and (b) (Inspection of work performed.).

<sup>32</sup>This language is required in maintenance entries for major repairs or alterations. (See Appendix B to FAR Part 43, Par. (b)(4).) Not all serviceable tags document major repairs or alterations.

<sup>33</sup>Title 14 CFR Part 145.73 (Foreign repair stations—scope of work authorized.) and Part 145.51 (Privileges of certificates.).

<sup>34</sup>Title 14 CFR Part 145, Subpart B and C.

<sup>35</sup>Title 14 CFR Section 145.79.

<sup>36</sup>See appendix E for examples of THY's repair station operations specifications.

<sup>37</sup>Limited ratings are ratings issued to repair stations for the performance of maintenance on particular makes and models of airframes, powerplants, propellers, radios, instruments, accessories, and/or parts. (8300.10 (Chapter 161, Section 1, paragraph (8) FAR 145.33.))

<sup>38</sup>Title 14 CFR Section 121.417.

<sup>39</sup>Fatigue striation measurements in the outboard fatigue region from SR hole "1" gave estimated uniform spacings of 2 microns between 10.5 mm and 15.5 mm crack lengths and an estimated uniform 2.5 micron spacing from 15.5 mm crack length to the fatigue terminus at 22.25 mm from the hole. These measurements were used to estimate the approximate crack length at the last inspection reported as 4,430 engine cycles before disk failure. The fatigue striation spacings of 2.5 microns and less were consistent with fatigue striation development from low cycle fatigue, which equates to one striation for each flight cycle. The final stages of fatigue cracking were used to calculate the amount of cracking to account for the last 4,430 striations, as follows: (22.25 mm minus 15.5 mm) or 6.75 mm of crack propagating at 0.0025 mm (equivalent to 2.5 microns) per cycle yields 2,700 cycles for this region; (4,430 cycles minus 2,700 cycles) or 1,730 cycles at 0.002 mm (2 micron) per cycle yields 3.46 mm; therefore, a crack of 6.75 mm plus 3.46 mm equals 10.21 mm to propagate the last 4,430 cycles. Because this crack had an overall length of 22.25 mm at failure of which the last 10.21 mm occurred since last inspection, then approximately (22.25 mm minus 10.21 mm) or 12.04 mm of crack length existed at the last inspection.

<sup>40</sup>A 12-mm crack extending the depth of SR hole "1," and extending to the front and rear faces of the disk would have a probability of detection of 100 percent when inspected with either FMPI or MPI according to the current Nondestructive Testing Information Analysis Center nondestructive evaluation capabilities data book.

<sup>41</sup>It is unclear what type of inspection THY performed, based on conflicting statements by the Director of THY's overhaul shop. In a meeting with Safety Board officials, he claimed that an MPI inspection was performed. However, subsequently, in a letter dated June 18, 1996, he stated that an FMPI was performed.

<sup>42</sup>DCA-96-MA-068, MD-88, Pensacola, Florida, 7/6/96.

<sup>43</sup>FAR 91.417 requires each owner or operator to keep certain records, including records of maintenance, alteration, and inspections (including a description of

the work performed, the date of completion, and the signature and certificate number of the person approving the aircraft for return to service); total time in service of airframes, engines, propellers, and rotors; records showing current status of life-limited parts; time since last overhaul of items required to be overhauled on a specified time basis; inspection status of the aircraft; status of airworthiness directives, including method of compliance; and copies of forms required for major alterations.

<sup>44</sup>National Transportation Safety Board. 1974. Safety Aspects of Emergency Evacuations from Air Carrier Aircraft. Special Study NTSB/AAS-74/3. Washington, DC.

<sup>45</sup>National Transportation Safety Board. 1979. United Airlines, Inc., N80820, Portland, Oregon, December 28, 1978. Aircraft Accident Report NTSB/AAR/79/7.

<sup>46</sup>National Transportation Safety Board. 1981. Evacuation of United Airlines DC-8-61, Sky Harbor International Airport, Phoenix, Arizona.

<sup>47</sup>Safety Recommendation A-79-64 had been classified "Closed—Acceptable Action" on April 6, 1981, based on the FAA's issuance of an NPRM.

<sup>48</sup>National Transportation Safety Board. 1991. Northwest Airlines, Inc. Flights 1482 and 299 Runway Incursion and Collision at Detroit Metropolitan Airport/Wayne County Airport in Romulus, Michigan, on December 3, 1990. Aircraft Accident Report NTSB/AAR-91/05. Washington, D.C.

<sup>49</sup>The FAA has advised the Safety Board of only one enforcement action in response to the Safety Board's 5/29/96 request to the FAA to provide a list of all enforcement actions related to in-lap infants.

<sup>50</sup>NYC-86-FA-076, L-1011, Jamaica, New York, 2/15/86; DCA-96-MA-029, B-747, Jamaica, New York, 12/20/95.

<sup>51</sup>Subsequent to this accident, ValuJet provided a cockpit key to all of its flight attendants.

<sup>52</sup>National Transportation Safety Board. 1991. Runway Collision of USAir Flight 1493, Boeing 737, and Skywest Flight 5569, Fairchild Metroliner, Los Angeles International Airport, Los Angeles, California, February 1, 1991. Aircraft Accident Report NTSB/AAR-91/08. Washington, D.C.

<sup>53</sup>"Slow Progress in Making Aircraft Cabin Interiors Fireproof" Report to Congressional Requesters. General Accounting Office, GAO/RCED-93-37, January 6, 1993.

<sup>54</sup>Safety Recommendation A-87-88 was classified "Closed—Acceptable Action" on December 23, 1988, following rulemaking by the FAA.

<sup>55</sup>DCA84IA029--June 23, 1984, Chicago O'Hare Airport; Tradewinds Airways Ltd., Flight 11, Boeing 707, G-SAIL; ANC85MA183--September 25, 1985, Dutch Harbor, Alaska, Mark Air B737, N674MA; DEN86FA080--February 20, 1986, Denver, Colorado, Continental Airlines, B737-300; DCA87IA015--December 18, 1986, Simmons Airlines, Flight 2860, ATR-42, N423MQ.

<sup>56</sup>(1) National Transportation Safety Board. 1994. Stall and loss of control on final approach of Atlantic Coast Airlines, Inc., United Express Flight 6291, Jetstream 4101, N304UE, at Columbus, Ohio, on January 7, 1994. Aircraft Accident Report NTSB/AAR-94/07. Washington, D.C. (2) National Transportation Safety Board. 1995. Uncontrolled collision with terrain of Flagship Airlines Inc., doing business as American Eagle Flight 3379, BAe Jetstream 3201, N918AE, near Morrisville, North Carolina, on December 13, 1994. Aircraft Accident Report NTSB/AAR-95/07. Washington, D.C.